PRODUCT ENGINEERING

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Engineering Recognition

ENGINEERING is gaining an increasing measure of recognition on its merits, and so are engineers.

Speaking before a group of technical editors, Paul G. Hoffman, Studebaker president, declares that the independent automobile company can maintain its position against the competition of the big manufacturers only by offering a better product for the money. Engineering is not the sole reason for competitive success, but it is the primary one.

To offset obvious advantages of the major producers the smaller competitor must contribute more than his share of engineering advancements. It is fortunate for him that the big units have never been able to monopolize the engineering brains of the automobile industry, or of any other industry.

In the employees' magazine of the Cincinnati Milling Machine Company, President Frederick V. Geier points out that the foundation of the success of the company is its engineering and research activity. He expresses his pride in the standing which the company has gained through engineering and gives full credit to the engineers themselves.

At the Annual Meeting of the American Society of Mechanical Engineers last month the major theme was appreciation of the work done by two great engineers, George Westinghouse and Ambrose Swasey. Prominent men from all walks of life recalled the many contributions of Westinghouse, the engineer, and Westinghouse, the man. Broad in scope these achievements were but based on engineering, every one of them. No less a figure than former President Herbert Hoover led the list of those paying tribute to Mr. Swasey, who celebrated his ninetieth birthday a fortnight later. His work in the machine tool field and in the field of telescopes and telescope mountings has been preeminently engineering.

Much more evidence could be produced to prove that engineers and engineering are recognized today at somewhere near their real worth. Such recognition is sweet but it carries with it a responsibility that is distinctly sobering. Of those whom we recognize and honor we expect more than we do of the average man. Engineers have had to shoulder staggering responsibilities during the dark days of depression. They are facing equally difficult ones in the year that lies ahead.

Volume 8

PRODUCT ENGINEERING starts its eighth year of service to product engineers, and its eighth volume, with this January 1937 number. It has weathered a major depression and has grown apace with the return of activity in business and industry. Its editors and publishers are grateful for the support given to their efforts by subscribers and advertisers alike. The staff that will edit Volume 8 is made up of George F. Nordenholt, editor; Kenneth H. Condit, consulting editor; Fred A. Firnhaber and Joseph Kerr, assistant editors; N. J. Van Ness; Paul Wooton, Washington.

Ball Bearings Used As Cam Rollers

THOMAS BARISH
Assistant Chief Engineer, Marlin-Rockwell Corp.

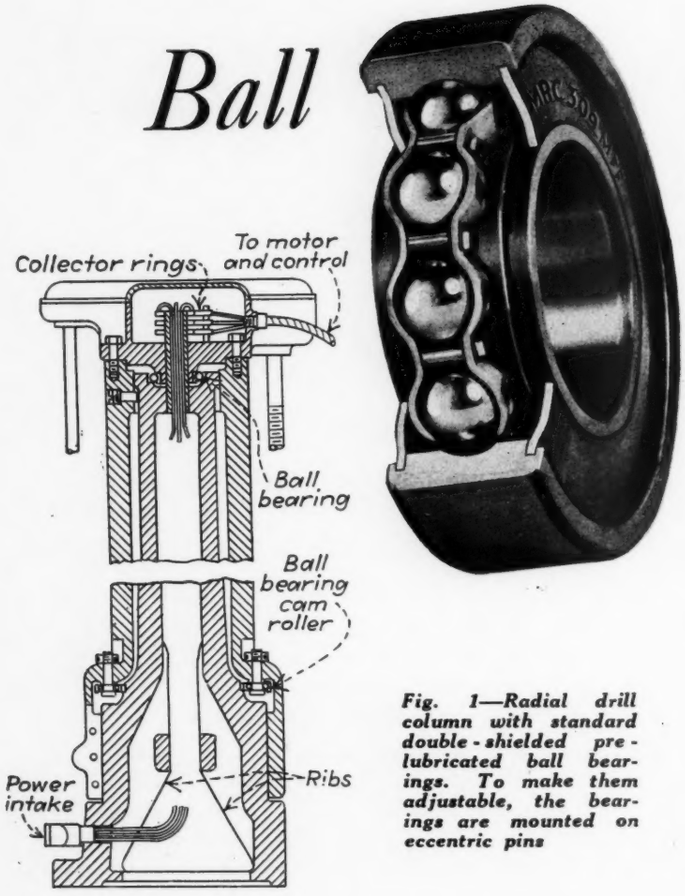


Fig. 1—Radial drill column with standard double-shielded pre-lubricated ball bearings. To make them adjustable, the bearings are mounted on eccentric pins

Because the stresses developed in a cam roller are so similar to those created by the contact between the ball and race of a ball bearing, the latter is inherently suitable to use as a cam roller. Typical applications, design modification and load-carrying capacity are covered in this article

BALL bearings are used extensively as cam rollers because of their availability as standard parts that can be readily purchased as a complete unit, and because the outer race material of the regular bearings has almost exactly the correct properties for the cam contact. This is to be expected since the loading conditions on a cam roller are so similar to those created by the contact between the ball and the race of a ball bearing.

The new permanently lubricated ball bearings have been very popular for slow-speed out-of-the-way applications where additional lubrication is quite difficult and practically unnecessary. Fig. 1 shows one of these standard double shielded bearings and a useful typical application of it as a radial support at the bottom of the column of a large radial drill to provide free movement for the column. The pins which carry the bearings are eccentric and readily adjustable to avoid cramping when the column is locked in operating position. Bearings in this location are of the double shielded and permanently lubricated type.

Another application wherein the speeds are much higher and the loads are heavy, is shown in Fig. 2. Here the ball bearing cam roller actually transmits the entire force to the piston of a pump for delivering oil at high pressure. The cam surface itself is of hardened and ground steel since it must carry the same high unit pressures that are applied on the outer surface of the bearing. The slight but definite freedom of the ball bearings to tilt permits them to align so that the contact on the cam extends uniformly across the whole face.

A special ball separator or retainer becomes necessary in this design because the bearing rotates around the axis of the pump at high speed and at a fairly large radius, thereby producing on the retainer a centrifugal force of several hundred times its own weight. In addition, the r.p.m. of the bearing changes rapidly as the cam radius varies during each pumping cycle. A radial type ball bearing with a one-piece retainer of special molded plastic material and supported on the O.D. of the inner race has performed excellently under these accelerating and centrifugal forces.

A new useful application of ball bearing cam rollers on machine tool ways is in the DeWalt cut-off saw, as shown in Fig. 3. The vertical rollers bear on the top side to hold the unit down, and the tilted rollers rest on a "V". The pins are eccentric to permit exact adjustment. Thus the rollers support the motor with the

saw mounted directly on the motor shaft. This type of machine tool way-mounting is rapidly becoming popular because it permits easier movement, more accurate settings, and much larger weights can be moved by hand.

The capacity of the bearing itself, (ball to race contact) is not the controlling factor in the selection of bearings for any of these applications, as there are two other limiting conditions, (1) the strength of the race under bending when the load comes between balls and (2) the Herz stress at the cam contact. One or both of these will be the controlling factor.

Calculations and tests were made to compare these two effects, and also to compare the Conrad type ball bearing, having fewer balls further apart and a continuous race, with the maximum capacity type which has more balls closer together but is weakened at the filling notch. Fig. 4 shows the test method with the load mid-way between two balls. To calculate the bending stress as a beam, the race was assumed laid out in a straight line as a continuous beam with load at the cam contact and supports at the two lowest balls and also at the top ball. This method of calculation is based on the consideration that the race flattens out under load and brings the top balls into contact. Table I clearly shows that the Herz stress at the rolling contact is controlling, particularly at lower operating loads where this stress is not reduced as much as is the bending stress.

[*For a presentation of the Herz equations, see pages* 555 *to* 561 *of Timoshenko, "Strength of Materials," part 2, D. Van Nostrand Company, publishers.*]

For maximum loading, the cam surface itself must be a hardened steel alloy and ground smooth. Ball bear-

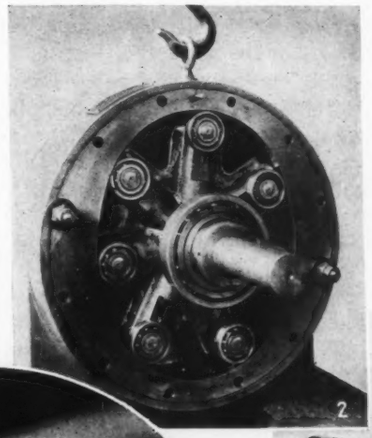


Fig. 2—Ball bearings used as cam rollers on a radial piston pump. Speeds and loads are relatively high, the entire force delivered to the pistons being transmitted through the bearings

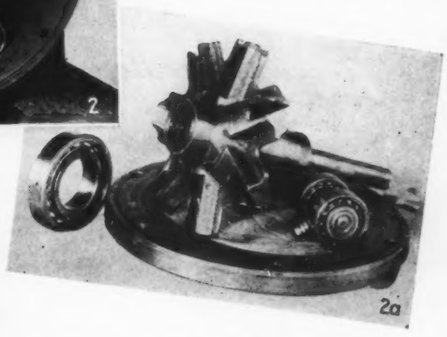


Fig. 7—This steering clutch throwout on Monarch crawler type tractors is a successful example of the use of ball bearings operating as cams against a hardened flat plate

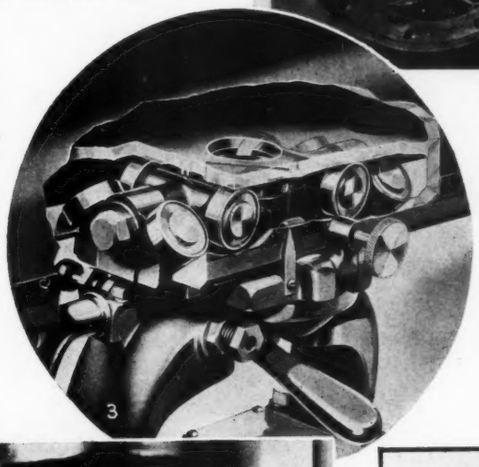


Fig. 3—In the DeWalt cut-off saw, ball bearings used as cam rollers to support the motor and saw unit

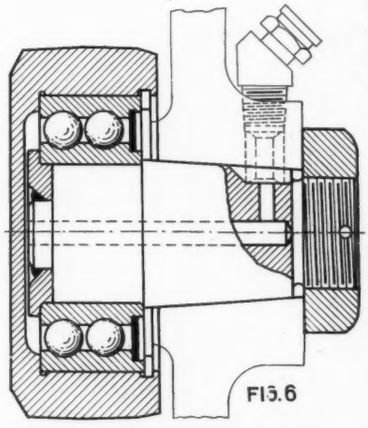


Fig. 6—In this design of separate roller piece and bearings, provisions are made for renewing the grease. It is used where foreign matter is likely to work into the bearings

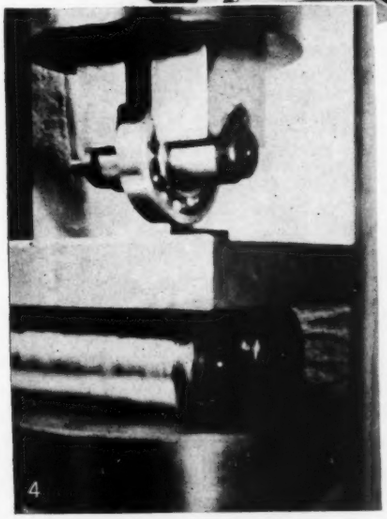
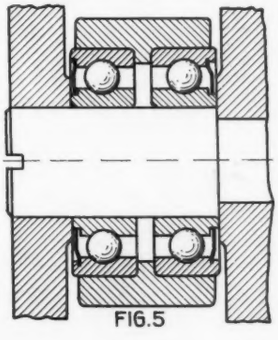


Fig. 4—Method of testing ball bearings to determine the maximum load they can carry

Fig. 5—Design of cam roller using a separate roller and two single shielded bearings, the spaces being filled with high-temperature grease



ing steel (SAE 52100) hardened to about 60 Rockwell C scale is recommended. Experience indicates that a contact stress of 80,000 lb. per sq. in. is allowable for normal service. Table II gives working loads for standard ball bearings, with or without shields.

For cam surfaces other than hardened alloy steel, smaller stresses should be used to avoid flaking of the cam. Table III gives the allowable loadings for different materials and conditions. Note that cast iron with a deeply chilled surface can approach hardened steel for this type of service.

The capacity table deserves emphasis. Loads on cam rollers should always be determined. Especially shock loads must be analyzed because of the very hard steel used both for cams and bearing races. This is especially true if the cam or bearing outer race have interruptions such as bolt holes or holes in the race.

For severe shocks a slightly softer and heavier section roller may be desirable. The roller can then be made as a separate piece mounted on separate ball bearings. Two light series ball bearings will practically always provide ample capacity. Single shielded bearings will leave a space between that can be filled initially with enough high-temperature grease to last for the life of the machine. Fig. 5 illustrates such a design.

Sometimes excessive wear from foreign matter cannot be avoided, as on the rollers supporting the drum of a concrete mixer. A separate roller piece permits inexpensive replacement and likewise takes care of unavoidable shock caused by pieces of foreign matter dragged over the roller, (See Fig. 6). Because of very dirty operating conditions, fresh grease is added to force the old grease out through the seals, and "grease clean" the bearing.

Special Applications

Two small ball bearing rollers operating against a hardened flat plate can be used to replace unnecessarily large and expensive thrust bearings. The steering clutch throwout on the Monarch crawler type tractor, shown in Fig. 7, is a successful example. The same stress and load limitations as given in Table II apply. The difference in speed between the ends of the contact area tend to twist the roller, hence a narrow single row bearing is desirable. Also, the axis of the ball bearing must very nearly cross the axis of the plate.

Another interesting application, the vertical support on a foundry molding machine, as shown in Fig. 8, uses ball bearings as cam rollers to obtain free sliding movement along the shaft, an axial sliding, and some slight angular movement. The cam contact in this case is unusual, being two cylinders with their axis at right angles to each other, as in Fig. 8, the contact area

TABLE I — TEST RESULTS AND CALCULATED STRESSES

Bearing Number	309 S	309 M
Balls, number and diam.	8 11/16	12 5/8
Broke at, lb	18,300	12,000
Bending stress (as beam) lb. per sq. in	244,000	236,000
Herz stress (cam contact) lb. per sq. in.	234,000	190,000
Resultant of bending and Herz, lb. per sq. in.	267,000	*222,000
Recommended rating (Table II)	2,060	2,060
Bending stress, lb. per sq. in.	26,480	40,200
Herz stress, lb. per sq. in.	80,000	80,000
Resultant of bending and Herz stress, lb. per sq. in.	81,000	*83,200

* No allowance for stress concentration at filling notch caused by the change in section.

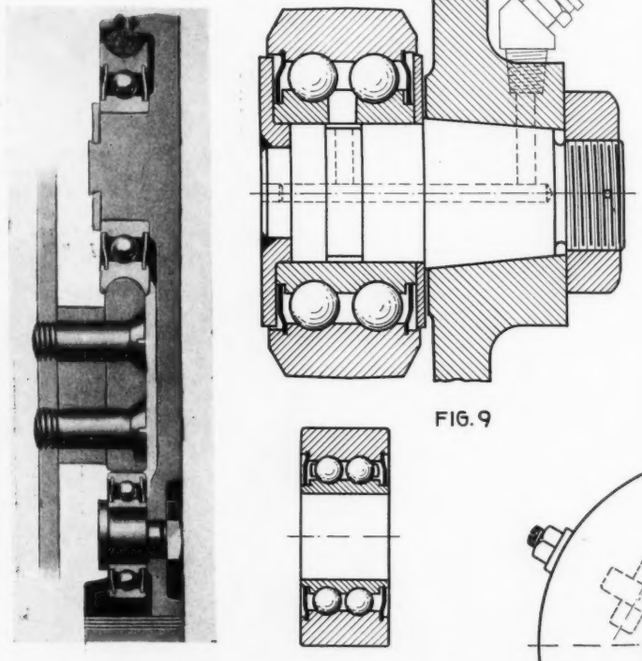


FIG. 9

Fig. 9 — Simple modifications of standard bearings for use as cam rollers subjected to shocks, the outer race being made heavier

Fig. 10 (Left) — Special bearings used for elevator doors, the door track being a special cold-drawn section

Fig. 8—Ball bearings used as cam rollers to obtain free axial sliding of a shaft. This design is used in the Tabor foundry molding machine

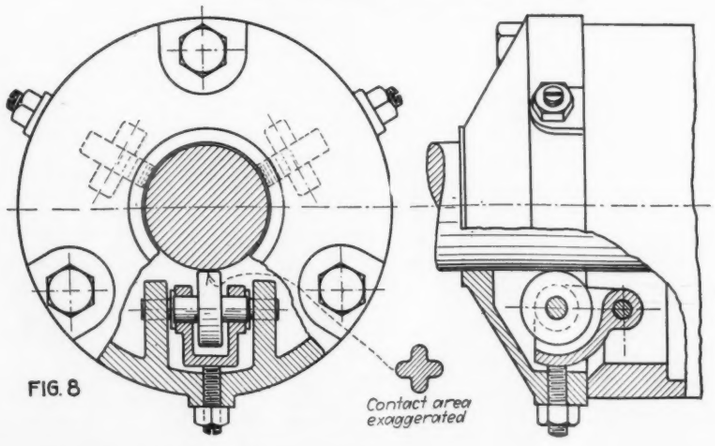


FIG. 8

TABLE II — WORKING LOADS FOR STANDARD BALL BEARINGS

R is the Radius of Curvature in Inches

Ball Bearing No.			Concave cam					Flat	Convex Cam				
			R = 2	R = 3	R = 5	R = 8	R = 12	R = ∞	R = 12	R = 8	R = 5	R = 3	R = 2
34			72	67	64	63	62	60	59	58	57	55	52
35	36		110	102	77	94	93	89	87	85	83	80	75
37	38		159	145	136	131	129	124	120	118	114	108	102
39			223	200	184	177	173	165	159	156	150	141	132
200			312	273	249	237	231	220	209	204	196	183	169
201			385	334	302	287	279	264	251	244	234	218	201
202	300		492	418	374	353	342	322	304	297	283	262	240
	301		550	461	403	384	371	349	329	320	304	281	256
203			620	495	447	418	404	377	354	344	326	299	271
	302		680	550	475	441	425	396	371	359	340	310	280
204	303		990	770	650	600	580	530	500	480	450	410	370
205	304		1300	970	800	730	700	640	590	570	530	480	420
206			2100	1380	1090	970	910	820	740	710	660	580	510
	305	403	2250	1480	1160	1040	980	880	800	760	710	630	550
207			—	1930	1430	1240	1160	1020	910	870	800	690	600
	306	404	—	2190	1620	1410	1310	1160	1040	980	900	790	680
208			—	2540	1760	1500	1390	1210	1070	1010	920	790	680
	307	405	—	2860	1980	1690	1560	1360	1200	1040	1030	890	760
209			—	3090	2050	1730	1590	1370	1200	1130	1020	880	740
210			—	—	2370	1970	1800	1530	1330	1250	1130	960	810
	308	406	—	—	2630	2180	1990	1700	1480	1390	1250	1070	900
211			—	—	2800	2250	2030	1700	1460	1360	1220	1030	860
	309	407	—	—	3420	2750	2480	2060	1780	1670	1490	1250	1050
212			—	—	3480	2700	2400	1970	1670	1550	1380	1150	960
	310	408	—	—	4210	3270	2910	2380	2020	1890	1660	1390	1160
213			—	—	4280	3220	2810	2260	1890	1750	1540	1270	1040
	311	409	—	—	5340	4050	3510	2820	2360	2180	1920	1580	1300
214			—	—	4860	3570	3110	2480	2060	1890	1660	1360	1110
215			—	—	—	3980	3440	2700	2230	2050	1790	1460	1190
	312	410	—	—	—	4890	4220	3320	2740	2520	2200	1790	1460
216			—	—	—	4430	3770	2900	2360	2160	1880	1520	1220
	313	411	—	—	—	5850	4960	3830	3120	2850	2470	2000	1610

being a distorted circle that approaches a square. The Herz theory was developed for this case and gave as a simple approximation:

$$\text{Stress} = C \sqrt[3]{\frac{\text{Load}}{\text{Radius}}}$$

Here C equals 39,000 when the two radii are equal and C equals 34,200 when the shaft radius equals 1.5 times the bearing radius. Because the contact area is no longer a long rectangle, very small capacities would be expected. In actual practice, the presence of a small amount of sand soon causes the softer shaft to develop a narrow smooth flat surface equal to about one-half the width of the theoretical contact area, after which the wearing off of the shaft greatly decreases.

Where large quantities are involved, standard bearings can be economically modified as specials for unusual cam roller applications. Fig. 9 shows two simple modifications, with a heavy outer race to withstand shocks.

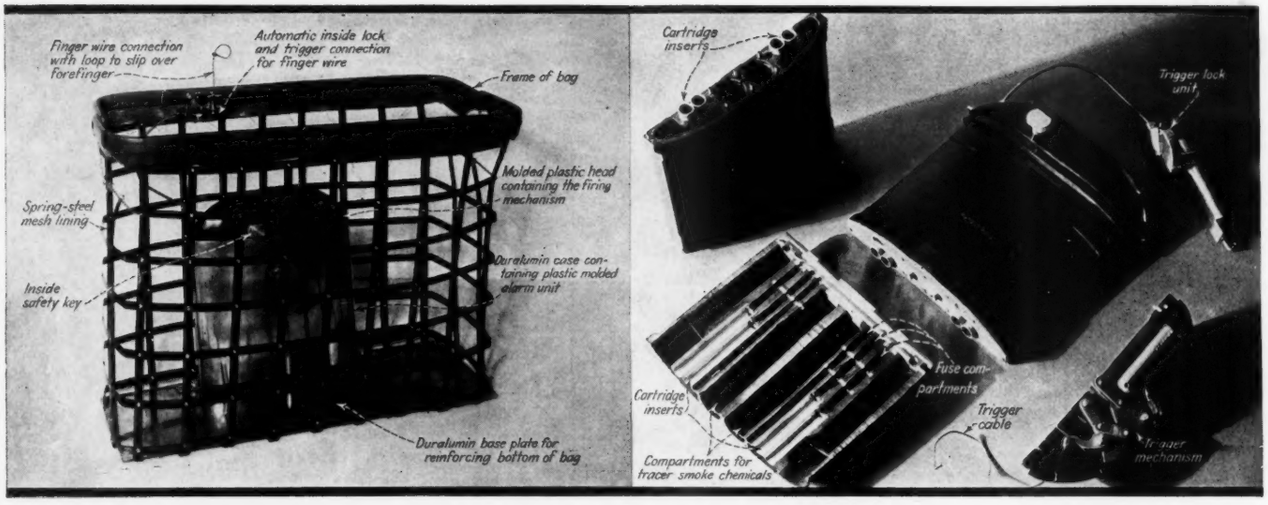
In Fig. 10 is shown another common special bearing used for supporting elevator doors to provide unusual smoothness and quietness. The curved outer race groove has a slightly larger radius than the bar on which it rides. This bar is a special cold-drawn section of unusual surface smoothness and accuracy. Here again the capacity of the cam contact would be low because it resembles two cylinders at right angles, Fig. 8, but the condition is corrected by grooving the outer race of the bearing and making its contour approach that of the bar, thereby giving a much wider contact area. Note the lower bearing of standard construction to act as a hold-down. Permanent lubrication is especially valuable here. Special applications such as these are best handled by making a separate roller fastened on the outer race of the bearing, as shown in Fig. 6, unless the quantities involved are large enough to justify the expensive tooling required for special bearings.

TABLE III
ALLOWABLE LOADINGS FOR VARIOUS CONDITIONS

	Allowable Herz Stress		Multiply Capacity (Table I) by following factor	
	Hardened Carbon Steel Cam	Cast Iron Cam	Hardened Carbon Steel Cam	Cast Iron Cam
Very intermittent (or max. loading shock)...	110,000	*40,000	1.9	*0.25
Normal Loading.....	80,000	*30,000	1.0	*0.14
Continuous Service.....	50,000	*20,000	0.4	*0.06

* These ratings may be exceeded approximately 50 per cent if continual flaking or wear of the cam surface is not objectionable.

PRODUCT DEVELOPMENTS


Finger wire connection with loop to slip over forefinger
Automatic inside lock and trigger connection for finger wire
Frame of bag
Molded plastic head containing the firing mechanism
Spring-steel mesh lining
Duralumin case containing plastic molded alarm unit
Inside safety key
Duralumin base plate for reinforcing bottom of bag
Cartridge inserts
Trigger lock unit
Fuse compartments
Cartridge inserts
Trigger cable
Trigger mechanism
Compartments for tracer smoke chemicals

Interior of Tracelarm messenger bag showing spring steel frame and duralumin and plastic case containing material for audible and visible alarm. (Right) Two-piece plastic-case showing metal inserts for blank cartridges in lower part and trigger mechanism in upper part

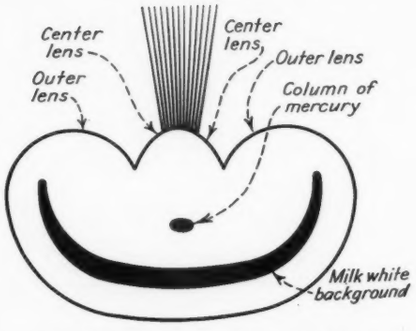
Modern Materials Used in Fabrication of Messenger Bag

● Molded plastics, duralumin, spring steel, flexible wire cable and cadmium plated parts are used in making the Tracelarm messenger bag manufactured by the Bankers Protection Company of Simsbury, Conn. The bag is used for carrying money and other valuables and is so constructed that if it is snatched by a thief not only is it automatically locked, but within 10 sec. an alarm is sounded and a dense cloud of tracer smoke is discharged, thereby making detection and apprehension of the snatcher possible.

In the illustration of the plastic parts of this bag is shown the sectioned view of the cartridge holder with the four tubular metal inserts molded into the case to hold the powder for the .45 caliber blank cartridges. Connecting these four chambers are various lengths of Ensign-Bickford safety fuses, different lengths being used to give four successive detonations. The two center chambers hold enough chemical for producing a yellow tracer smoke for three minutes or more.

The upper part of this plastic housing is equipped with dual-ignition mechanism to insure positive operation of the alarm. No batteries are used. To save weight the lower part of the plastic molding is housed in a duralumin case and the base plate for reinforcing the bottom of the bag is also made of duralumin. The frame of the bag is made of spring steel so that it cannot be cut open quickly.

Concealed between the handles of the bag is a fine wire cable with a loop that slips over the messenger's forefinger. This cable operates the trigger mechanism within the bag and although it permits ample free movement, if the bag should be snatched from the messenger, the loop tightens on the finger and the wire pulls away from the connection within the bag. This movement instantly closes the automatic inside lock and also trips the alarm mechanism without any noise. The discharge outlets are at the bottom of the bag and are concealed by a leather cover which comes off when the alarm operates.



Angle of vision is increased by virtue of wider background which catches light rays from three lenses concentrating them without reflection on the column of mercury

● *Three-Lens Tube for Easy Reading*

Readability of thermometer indications is improved in the Taylor "Binoc" tube because of the shape of the lens. Whereas the angle of vision was narrow in the type of single lens tubing used previously, the new product has three lenses as illustrated, thereby increasing the angle of vision and allowing easier reading in that the triple lens construction gathers three times the amount of light.

The center lens is so formed that the intensity of light concentrated upon the mercury column is greatly increased. The two outer lenses

gather light and focus it upon the contrasting milk-white background, directly behind the mercury column which, magnified, stands out in sharp relief. This opaque background extending towards the front also diverts any light rays that would normally produce bore reflections.

• *Redesigning Tractor to Eliminate Projection*

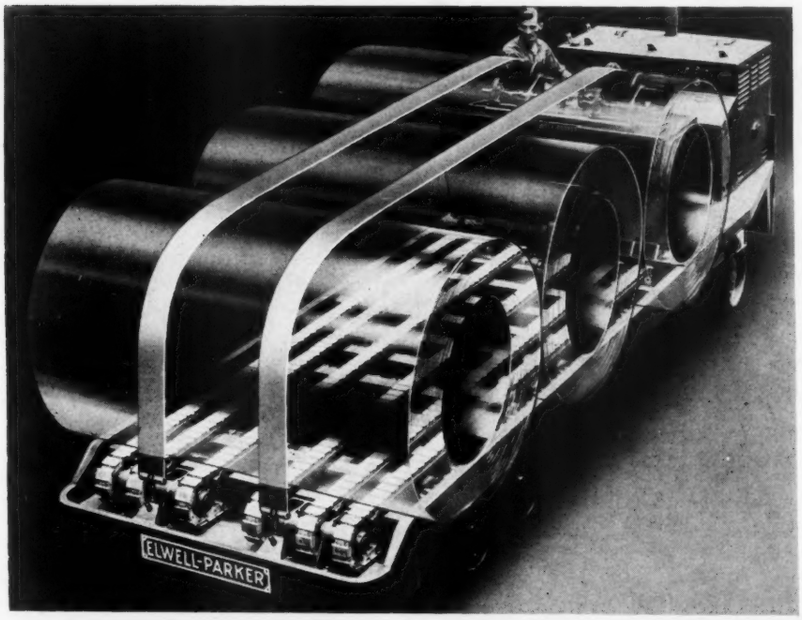
When using a tractor for cultivating between fruit trees in citrus groves it was found that protruding parts of the tractor bruised the low-hanging fruit and causes abrasions on the trunks and branches. With this in mind, the Cletrac tractor was redesigned by Lawrence Blazey of Designers for Industry, Inc.

Skirts or guards are placed over the traction chains to protect the tree trunks. In the previous design, as illustrated at the left, the exhaust pipe and the air filter projected above the engine hood. In the present design, as shown at the right, this pipe is positioned so that the exhaust gases are deflected under the chassis and the air filter is placed beneath the gas tank.

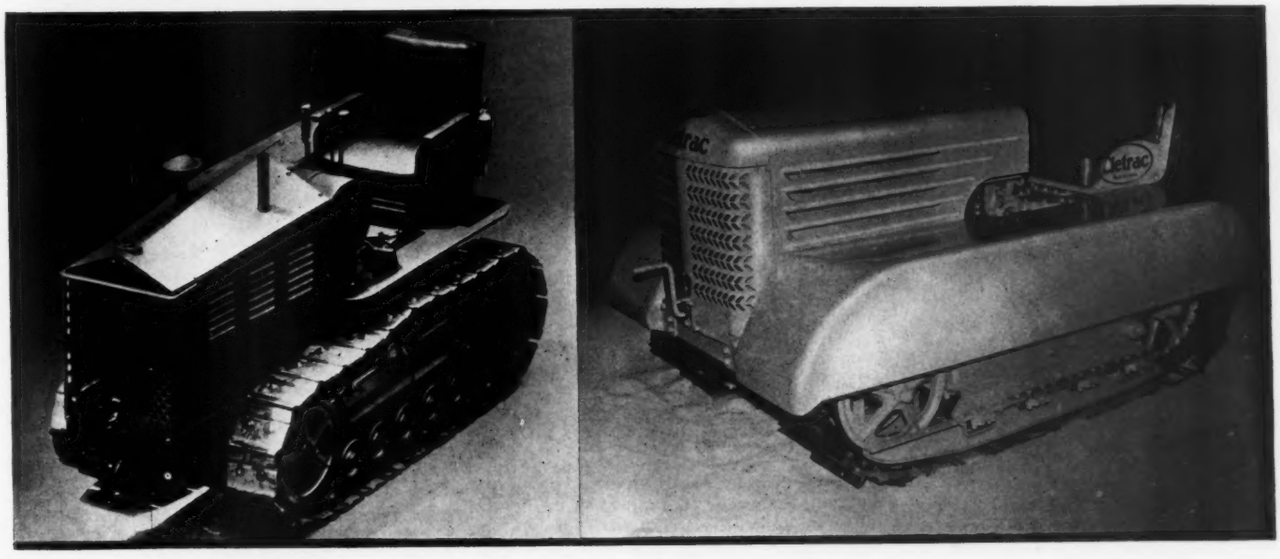
The engine hood has been extended to cover the gas tank and the operator's seat lowered to conform to the shape of the engine hood. Whereas small operating pedals were formerly used, the new pedals conform to the overshoes usually worn by the operators, and a foot rest is provided for greater comfort. Shifting levers have been shortened to fit below the hood and the lever grips made more comfortable to the hand. Louvres project inwardly to give a smooth surface to the outside of the hood and the radiator cap and gas tank cover are also set flush with the top.

• *Multiple Conveyor Chain on Truck*

What is said to be the first application of a chain loading conveyor ever placed on a truck has been recently designed and built by the Elwell-Parker Electric Company. It is used primarily to handle three steel coils by pulling them onto or rolling them off the platform from a continuous pickler, and for transporting them to cold reduction mills one-half mile distant. The six roller conveyor chains have a forward and backward motion and by means of clutch handles to the right of the operator, can be operated in two sets of three, the speed of movement depending on the speed of a gas-



Two sets of three roller conveyor chains with a center distance of more than 12 ft. between sprockets are used to load, unload and carry coils of sheet steel

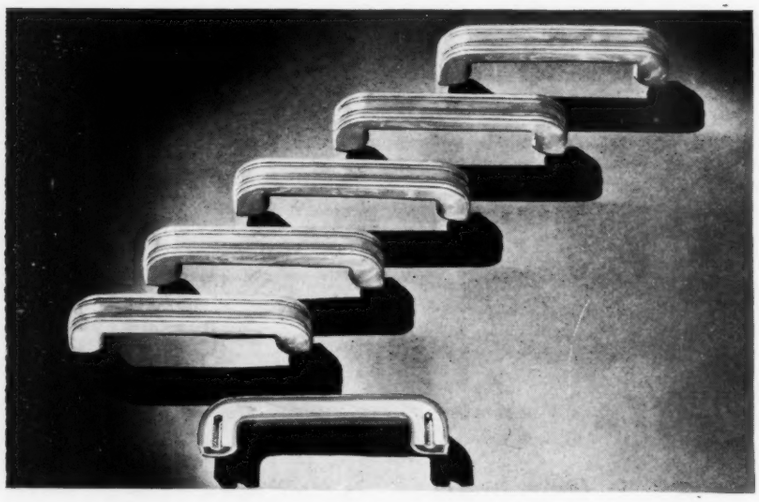


All protruding parts on Cletrac tractor have been eliminated to prevent damage to low-hanging trees in citrus groves. For color harmony in the new design, orange trimmed with yellow and upholstery of brown leather are used

electric unit with foot accelerator control.

The conveyor sprockets are mounted on anti-friction bearings. The chains are guided in channels to prevent sagging and are so spaced that 60 in. diameter coils 18 in., 36 in., and 76 in. wide can be carried. The 18-in. wide coils are carried on the inner chains of either the right or left-hand set, and 36-in. wide coils are carried on the three chains of either sets, while all six chains are used to support 76-in. wide coils. Should it happen that the largest coil is not set straight across the platform of the truck, it can be straightened by operating the conveyor unit on one side, while the other remains motionless. When the truck is in motion, the coils are prevented from rolling by two hold-down straps as shown. Two winches near the operator's position are used for tightening these straps. When loading and unloading, the straps can be disconnected by simply unhooking them from the chassis.

The 21-ft. chassis is of welded construction and is mounted on six solid rubber tired wheels. The two front drive tires are $22\frac{3}{4}$ in. diameter by $14\frac{7}{8}$ in. wide; four trail tires are each $18\frac{1}{4}$ in. diameter by 14 in. wide. The truck can turn on all six wheels and is steered by electric motor through a gear reduction unit. Fully loaded, the truck can travel 4.5 mi. per hr. It weighs 23,000 lb. and has a rated capacity of 40,000 lb. but has carried 53,000 lb. during tests.



Refrigerator door handles made of Tenite, ⅛ in. thick, which is molded over zinc core ¼ in. thick by 4 in. long

Combination automobile, tractor and boat used successfully in transportation of men and equipment in Louisiana swamps for discovering oil. The vehicle weighs 7,500 lb., is 22½ ft. long and is powered by a Ford V-8 engine

• *Plastic Molded Handle With Zinc Core*

What is said to be the first time that a comparatively large metal core has been successfully coated on a production basis with a relatively thin plastic covering, is announced by the Erie Resistor Corporation in their description of refrigerator door handles they make for the Stewart Warner Corporation. These handles have a zinc core ¼-in. thick by 4 in. long, and a shell of Tenite, ⅛-in. thick is molded around this zinc core. No finishing operation other than the removal of one gate is necessary. The zinc castings are used as they come from the die and any variation in size is compensated for in the plastic molding operation. The ends of the handles are uncoated so that the holding screws thread directly into the zinc core.

• *Buoyancy of Tires Makes Tractor a Boat*

As an aid in discovering oil in the marshes of Louisiana, the Gulf Oil Corporation has built a vehicle known as the "marsh buggy," a combination automobile, tractor and boat, used for transportation of geophysical crews and equipment. The machine can be operated either on land, in waist-deep mire, or in water of any depth. The 7,500-lb. vehicle is $22\frac{1}{2}$ ft. in length and is powered by a Ford V-8 engine, equipped with an over-sized cooling system. At the rear of the motor is a regular passenger car transmission coupled in series with a McCormick-Deering tractor gear box. The tractor transmission is fastened rigidly to the frame and the rear wheels are mounted on the ends of extended axles. The combination of the two transmissions provides ten forward and six reverse speeds.

The front wheels receive power by chains and sprockets from the rear axles. The tractor has two separate transmissions, one for the wheels on the right, the other for the wheels on the left. Hence the vehicle can be driven by all four wheels or by the two wheels on either side.

The front axle is pivoted at the center in such a manner that either front wheel can rise two feet without distorting the frame. The front

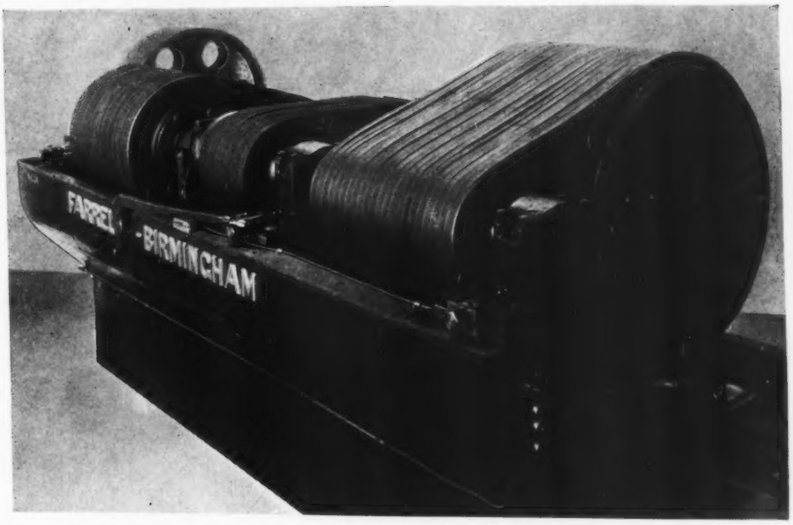
wheels have a regular toe-in and caster and the steering mechanism is similar to that of a motor car. The tires, designed and fabricated by the Goodyear Tire & Rubber Company, are the largest ever molded, being 10 ft. high by 3 ft. wide, and are mounted on 66-in. rims. The displacement of the tires is such that the vehicle floats in less than two feet of water. Should a tire become punctured, a constant pressure in the tire can be maintained by starting a compressor which feeds air into the tube. When traveling in water or in marshes, traction is obtained by attaching twelve strands of 2-in. rubber hose to each wheel. Each piece of hose is sealed at both ends and is provided with an air valve for inflation to a pressure of 25 lb. per sq. in. Air pressure of 6 lb. per sq. in. is carried in the tires.

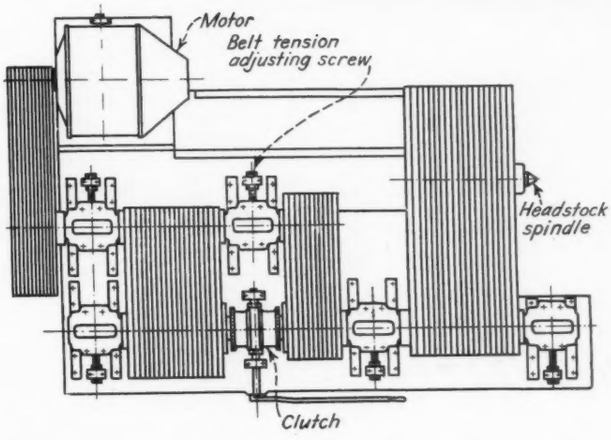
The main frame consists of an automobile chassis to which aluminum sections have been added front and rear. The side frames projecting from the chassis and the platform upon which men and equipment are carried, are also constructed of aluminum. This same metal is used for the four drum-wheels which contain sufficient air to keep the machine afloat, even though all four tires are completely deflated. The buggy can be operated over smooth ground at a speed of 35 mi. per hr., and is capable of navigating the marshes at 10 to 12 mi. per hr., while the speed in water is slightly in excess of 6 knots.

• *V-Belt Drive for Roll Grinder Headstock*

To insure smooth running, thereby avoiding possible vibration and chatter marks on the finished rolls, the headstock of the heavy duty roll grinder manufactured by the Farrel-Birmingham Company has a four-step reduction multiple V-belt drive. When grinding rolls up to 60 in. in diameter, and up to 24 ft. in length, it has been found that not only better finish, but also shorter grinding time is obtained with this type of drive.

A 25-hp. motor is required to drive the headstock and since the maximum power is required to start the roll turning, the motor is of the constant hp. type, with speed adjustable from 300 to 1,200 r.p.m.





The headstock drive on this large roll grinder contains 65 V-belts. Anti-friction bearing housings are separately adjustable for proper belt tension. Diagram shows the four speed reductions from motor to spindle

A total reduction of 50 to 1 from the motor to the headstock spindle is obtained solely through the use of V-belts. As shown in the accompanying drawing, a 7-in. pitch diameter pulley on the motor drives a 41.5-in. diameter pulley with 12 belts size *C*, $\frac{7}{8}$ in. by $\frac{17}{32}$ in. thick From this shaft, the drive passes through a two-speed shaft operated by a dog clutch. The high speed reduction has 11 size *D* belts, $1\frac{1}{4}$ in. wide by $\frac{3}{4}$ in. thick, running on two 18.37 in. pitch diameter pulleys, while the low speed reduction is from 11.0 in. to 29.3 in. diam. pulleys having 20 *D* belts. On the last reduction, 22 belts, *E*, $1\frac{1}{2}$ in. wide by 1 in. thick, run over 16.55 in. and 55.15 in. pitch diameter pulleys. There are a total of 65 belts of which either 54 or 45 belts are in use at one time, depending on the reduction required.

The various reduction pulleys are mounted on precision, anti-friction bearings in adjustable housings, each housing being adjustable separately to give proper tension to the belts without the use of idler pulleys. This adjustment, made through a hand hole in the cover, can be seen in the illustration. The metal tubes that carry lubricant to each bearing have a coil in each line to take up the change in length.

• *Random Jottings About New Developments*

What is thought to be the tallest pre-fabricated steel stack ever manufactured, was erected recently at the plant of R. G. LeTourneau, Inc., of Peoria, Ill. This all-welded stack is 104 ft. tall, 57 in. in diameter and weighs approximately 10 tons. It was made of $\frac{1}{4}$-in. plate.

* * *

One company is packing sealed precision ball bearings with a grease that is pre-tested for maximum stability, and as a precaution against the effects of grease oxidation, is wrapping them in aluminum foil for shipment and storage.

Types of Insulated Conductors for Electrical Apparatus

JAMES R. BECKER
Materials Engineer
Westinghouse Electric & Mfg. Company

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Service factors and physical characteristics of the materials that govern the design and structure of insulated cables and wires with reference to their use in electrical appliances and apparatus

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COMMON TYPES OF BARE AND INSULATED ELECTRICAL CABLES SHOWING CONDUCTOR, SEPARATOR, INSULATION AND BRAIDING

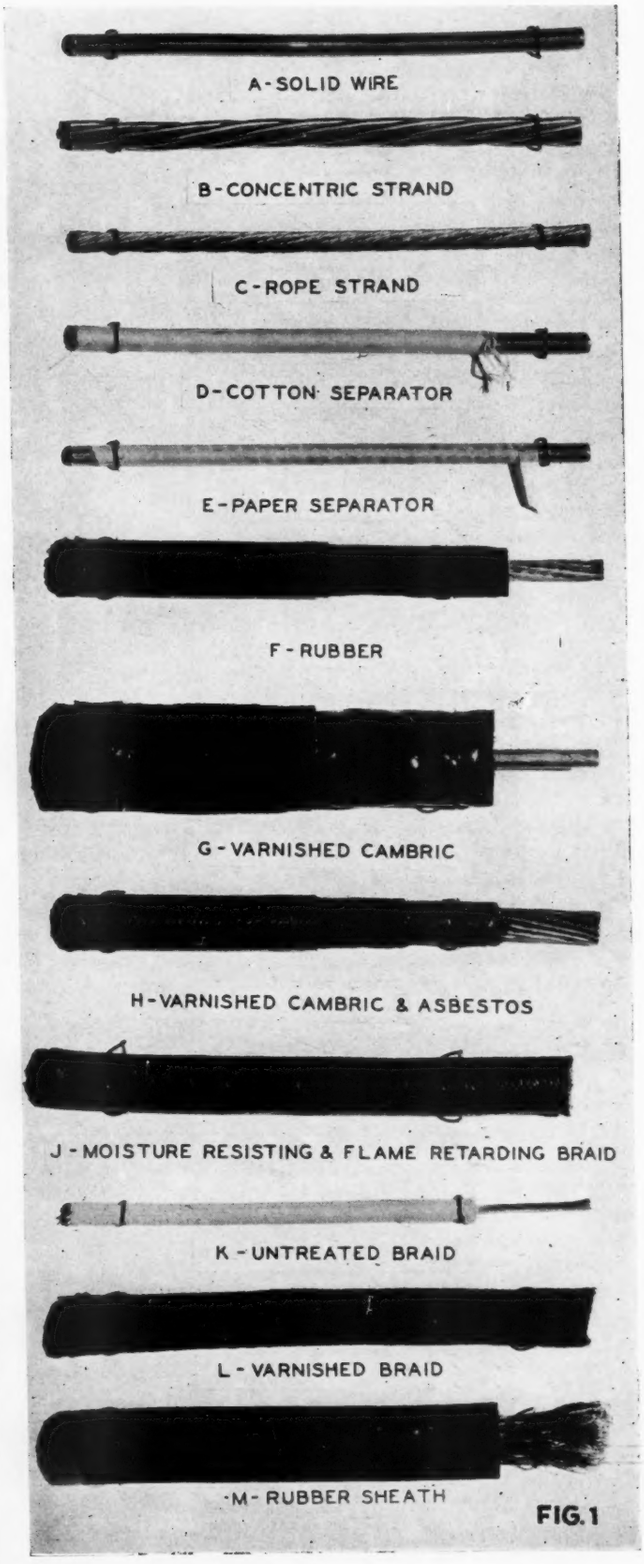


FIG. 1

HIGH voltages, increased speeds and more compact designs for built-in applications of electrical apparatus have caused designers to review thoroughly the fundamentals affecting the use and construction of insulated cables of all types ranging from the fine tinsel cord to the heavy lead sheathed cable.

Listed from the center to the periphery, the components of an electrical cable are conductor, separator, insulation, covering and saturant. The conductor is generally of copper, because of its relatively low cost, low electrical resistivity, and ease of working.

The use of tinsel cord is recommended where the current to be carried is very small and great flexibility is important. This conductor is composed of fine copper ribbons wrapped around cotton threads to provide flexibility and strength. Its use is limited by the Underwriters' Laboratories to portable appliances rated at not over 50 watts and an 8 ft. maximum length of cord. This type of conductor is used with curling irons, telephone receivers and electric clocks.

A solid wire, as shown in Fig. 1 (*A*), is preferable to other types if it is not to be subjected to frequent bending or excessive vibration and if it is not to be pulled through conduit containing many bends. It is cheaper, has the better space factor, and "stays put" better than stranded cable.

If a stranded conductor is desired or required because of the need of flexibility either during or after installation or because its size precludes the use of a single wire, the choice of the degree of flexibility is almost unlimited.

Ordinary strandings are of two types; concentric and rope. The concentric shown in Fig. 1(*B*), has one solid wire for the core and other wires of the same diameter are placed around it in layers. Each successive layer is given a spiral twist, generally in the opposite direction to the layer under it. From the geometry of the assembly the number of wires in any layer of a concentric strand contains 6 more wires than the layer immediately beneath. Table I shows the manner in which a concentric stranded cable builds up.

Rope stranding, shown in Fig. 1 (*C*), differs from the concentric type in that instead of the core and layer units being solid wires they are stranded. The simplest rope strand consists of 49 wires, made up by using a central 7 wire concentric strand and placing 6 similar 7 wire strands around as a layer. A few common rope strandings are—133 wires (19x7), 361 wires (19x19), and 703 wires (37x19). The order of stranding following the number of wires is important. For example, in the 133 wire strand, the order is given as (19x7), which means that there are 19 units of 7 wires each. If it were written (7x19), it would mean 7 units of 19 wires each.

Rope stranding is more flexible than concentric stranding and has greater fatigue life because there is less strain on the individual wires when the conductor is bent, since the arrangement of the wires in the rope stranding permits more movement of the wires.

Another type of conductor, suited for certain special requirements, has the wires braided together. This provides good flexibility with the added advantage that an individual wire cannot fray out or unravel if it broken in service. Where spacing in apparatus is close and an insulated conductor is not desirable, the use of a braided bare conductor will minimize the chance of a short circuit should an individual wire break.

Not only are round cross-sections of braided conductors obtainable but also rectangular shapes which are made by braiding a round tube of wires and rolling it flat, taking extreme care not to damage the wires by rolling too hard. Where small bare conductors are used in short lengths, the braided type is desirable since it does not unravel in handling like concentric or rope strandings. This type of conductor is used on electric contactors, small circuit breakers and other applications where concentric or rope strandings are unsuitable. Fig. 2 illustrates the use of five flat braided cables connected in parallel on a unit switch assembly.

The factors given in Table II will be of assistance in figuring the diameter over the bare conductor for a given strand. To obtain the overall diameter the individual wire diameter is multiplied by the factor.

EXAMPLES: (1) Concentric stranding 19 wires, each 0.040 in. in diameter. Diameter over strand = 5x0.040 in. = 0.200 in. (2) Rope stranding 133 wires, (19x7) each 0.010 in. in diameter. Diameter over strand = 15x0.010 in. = 0.150 in.

A formula giving approximate results for obtaining the diameter of a stranded conductor where large numbers of wires are involved and the exact makeup is not known is

$$D = 1.56d\sqrt{N}$$

Where D = diam. of strand, d = diam. of individual wires, and N = number of wires in strand.

EXAMPLE: For stranding 225 wires, each 0.0201 in. in diam., the diameter over strand = $1.156 \times 0.0201 \times \sqrt{225} = 0.349$ in.

As the name implies, separators are used to separate the conductor from the insulation. They facilitate stripping the insulation from the cable or wire for terminals, and are used almost exclusively on rubber insulated conductors.

Separators ordinarily consist of either a spiral wind

TABLE I — CONCENTRIC STRANDED CABLE

Layer	Wires in Layer	Wires in Core Strand	Strands in Cable
1	6	1	7
2	12	7	19
3	18	19	37
4	24	37	61
5	30	61	91
6	36	91	127
7	42	127	169
8	48	169	217

TABLE II — FACTORS USED IN CALCULATING OUTSIDE DIAMETER OF BARE STRANDED CONDUCTORS

Concentric Stranding		Rope Stranding		
Number of Wires	Factor	Number of Wires	Order of Stranding	Factor
7	3	49	7 x 7	9
19	5	133	19 x 7	15
37	7	259	37 x 7	21
61	9	427	61 x 7	27
91	11	637	91 x 7	33
127	13	703	37 x 19	35
169	15	889	127 x 7	39
217	17	1183	169 x 7	45

of cotton yarn or threads as shown in Fig. 1(*D*), or, as shown in Fig. 1 (*E*), a spiral wrap of thin paper.

Three distinct types of insulation are generally used for cable and wire used in electrical apparatus—rubber, varnished cambric, and asbestos. Rubber insulation, shown in Fig. 1(*F*) is flexible, non-hygroscopic, and easily spliced or terminated. However, it is susceptible to ozone and oil attack, deterioration at comparatively low temperatures and has low current carrying capacity.

Three of the various rubber compounds available for cable and wire insulations are the Code grade, 30 per cent Hev a grade, and Performance grade.

The Code grade is that covered by the Underwriters' Laboratories' Standards. It is used for applications having low electrical and mechanical stresses.

The 30 per cent Hevea grade, so called because it contains 30 per cent by weight of the best quality unused Hevea rubber, is a high quality insulation.

The Performance grade, rapidly becoming more popular, meets definitely specified electrical, physical, and aging requirements without limiting the manufacturer to very definite chemical requirements.

In addition to these three grades of rubber insulation are the special grades, developed for specific applications, which include compounds that resist heat and the deteriorating effect of ozone which is produced in the presence of corona.

Varnished cambric, shown in Fig. 1(*G*), has advantages over ordinary rubber compounds in that it has a higher temperature rating and current capacity, and greater resistance to ozone and oil. Its disadvantages are less flexibility and higher hygroscopicity. The use of asbestos as an insulation has made rapid strides lately, in applications where high temperatures or fire hazards are present. Asbestos does not possess the electrical properties of either rubber or varnished cambric. Where comparatively high electrical stresses are encountered along with either a high temperature or fire hazard, it is customary to apply varnished cambric over the conductor followed by a layer of asbestos, as shown in Fig. 1(*H*). The combination provides rather good electrical properties, considerable resistance to the deteriorating effect of heat and freedom from fire hazard. Rubber is sometimes used in place of the varnished cambric, but its use is not nearly so common.

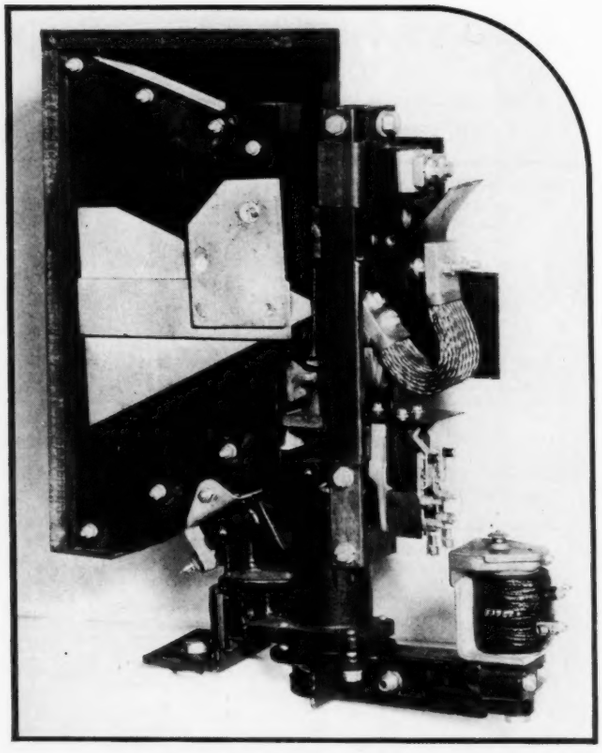


Fig. 2—Unit switch assembly using five flat braided cables connected in parallel

In general, rubber insulation is recommended for all types of low voltage applications. These include flexible cords for all appliances except heating, internal frame wiring and leads in motors, control circuits, elevator circuits, toy transformer leads, coil leads, house and factory wiring, battery chargers, railway car wiring and railway jumper cables. Ignition cables, gas tube sign cable, and X-ray apparatus leads, although operating at higher voltages, are usually insulated with rubber compounds of special types suitable for the application. The Underwriters' Laboratories permit the use of rubber insulation in ambient air where temperatures of 120 deg. F. are not exceeded.

Varnished cambric insulation is recommended for oil filled power transformers, oil filled circuit breakers, high voltage applications where the presence of corona is likely, leads of apparatus in oily locations, and high current wiring in dry locations. The Underwriters' Laboratories permit the use of varnished cambric insulation in ambient air temperatures not exceeding 167 deg. F. provided location is permanently dry.

Asbestos insulation is recommended for dry, high-temperature applications such as rheostat wiring, range wiring, waffle iron connections, lighting fixtures, and boiler room wiring. In combination with varnished cambric it is used for switchboard wiring, also for internal wiring and leads for high-temperature motors. In combination with rubber, it is being used for leads on subway car motors.

Practically all apparatus cable and wire insulation is protected with a braid such as is shown in Fig. 1(*K*) in preference to other covering. As braids are entirely adequate to the service, the additional weight and expense of the other types do not justify their use. Braids are usually composed of cotton; but where temperatures are high, asbestos braids are specified.

For some applications a high-grade rubber sheath, shown in Fig. 1(*M*), is often desirable, and is recommended where the cable or cord is subject to abrasion, excessive dampness, and weak acids. Arc welding cables, some railway motor and jumper cables, battery charger leads, sweeper leads, garage and factory extensions, and under water flood light leads, are representative examples of applications where the all-rubber sheath is recommended.

Braids used on cables and wires are almost without exception saturated with a preservative. Fig. 1(*J*) shows a combination moisture-resisting and flame-retarding compound recently developed which is admirably suited for the braids of cables and wires used on electrical apparatus. It has been approved by the Underwriters' Laboratories.

Varnish neither affects nor is affected by insulating oil, it also provides a protection for braid. Fig. 1(*L*) shows a sample of cambric insulated cable saturated with varnish for applications which are immersed in oil.

Developments in Bearings and Bearing Materials

A. B. WILLI
Chief Engineer, Federal-Mogul Corporation

A comprehensive analysis of the characteristics and advantages of and improvements in various types of precision sleeve bearings with suggestions for design, selection and application

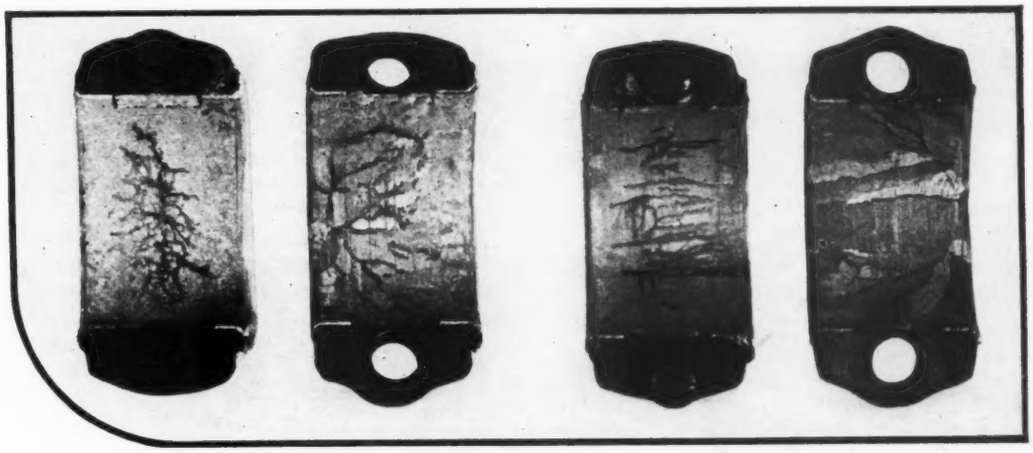


Fig. 1.—Worn connecting rod bearings lined with tin-base babbitt showing advanced stages of failure. In bearing at right cracks follow boundaries of large grains

FOR a number of years metallurgists have been searching industriously for improved bearing materials capable of withstanding heavier loads and higher speeds at reduced costs. The demand for such bearings was originated primarily by builders of automotive engines.

One of the outstanding contributions to improve bearing materials has been the development of the cadmium-silver bearing which is now widely used for automobile crankshaft and connecting rod bearings in an increasing number of internal-combustion engine models. Although these alloys were not commercially available prior to 1935, more than 20 different current production engine models, including high-speed passenger car engines, heavy-duty truck and bus engines, aircraft and diesel engines of two and four cycles, are now using cadmium-silver bearings. This seems to indicate the definite superiority, in this field of service at least, of cadmium-silver bearing metal over the conventional tin-base babbitts.

Bearing pressures of 1,400 lb. per sq.in. are considered the maximum permissible for some of the better tin-base babbitts, with PV (pressure-velocity) values of up to 40,000 ft.-lb. per min. per sq. in. of projected area. Operating under loads of 2,000 lb. per sq.in. and PV values of up to 65,000 and 70,000 ft.-lb., cadmium-silver bearings are being successfully used.

In certain two-cycle diesel engines, bearing loads as high as 3,300 lb. per sq. in. have been successfully handled and in similar types of engines operated under similar conditions, babbitt bearings carrying a 1,600 lb. per sq. in. load failed in relatively short periods. Another illustration of the value of the cadmium-silver bearing is shown in the case of a certain automobile which normally runs at exceptionally high temperature; babbitt bearings failed by cracking and crumbling from fatigue after 1,000 to 1,500 mi. of top speed operation. Cadmium-silver bearings lasted from 15,000 to 25,000 mi. under similar conditions of operation.

The inherent advantages of cadmium-silver as a bearing material are:

1. Greatly increased load-carrying ability.
2. Higher melting point—approximately 135 deg. F. higher than tin-base babbitts.
3. Lower coefficient of friction which permits a cooler running bearing.
4. Higher physical properties at all operating temperatures and prolonged high temperature operation has little effect on its strength and hardness.

One important consideration relative to the use of cadmium-silver bearings with a crankshaft is that the hardness of the shaft must be maintained at a minimum of 250 Brinell.

When this type of bearing is specified for an original design, attention should be paid to the following:

1. Thickness of the steel back to insure that the proper stiffness factor is maintained.

2. Thickness of the lining—excessively thin linings should not be used.

3. Type of finish on steel back which should be ground truly round and smooth to provide contact in the saddle bore at all points, this promoting maximum heat conductivity away from the bearing lining.

4. Means for properly distributing the lubricant, which involves a reasonable system of oil grooving to insure a full and complete oil film in the highly loaded areas.

5. Oil clearance—For different types of engines the oil clearance must be carefully determined. Cadmium-silver bearings operate with the same clearances as babbitt providing the babbitt clearance has been correct, but there are instances where the oil clearance of babbitt bearings has been too small for proper bearing life. Obviously, in such engines when the babbitt is replaced by cadmium-silver, an increase in clearance is required if full benefits are to be realized.

High-Lead Babbitts

High-lead babbitts are receiving careful attention from most bearing manufacturers. One alloy, L-100, possesses high ductility with no tendency towards harmful segregation in casting or spinning. This high-lead babbitt has been adopted for cam bearings in 14 current production engines. Tests of this material in main and connecting rod bearings in some engines have shown surprisingly good results.

Up to the present time this material has not been generally used for main and rod bearings pending the results of additional experimental work in various types of engines. Other high-lead bearing alloys have been introduced from time to time, but their field of usefulness in automotive engines heretofore has been limited. Other high-lead alloys may have a definite place for automotive engine bearings and within a certain range of bearing pressures, speeds and temperatures show marked improvements over the tin-base babbitts. However, a more complete knowledge of the exact range of usefulness of these bearings appears to be required before any general trend towards their adoption for the heavier loaded and higher speed bearings is justified.

Tin-Base Babbitts

The life and load-carrying abilities of certain tin-base babbitt alloys have been increased by paying strict attention to those phases of processing which control the grain or crystal structure. In Fig. 1 are shown four connecting rod bearings in advanced stages of failure, having been etched to show up the grain structure. Particularly, in the bearing at the lower right corner, can be seen the large and non-uniform grain structure and the cracks following exactly along the grain boundaries.

In Fig. 2 is shown the etched surface of a properly processed tin-base babbitt bearing. The grain structure here is very fine and uniform. But if a structure is too fine, the babbitt may be brittle. The load-carrying ability of the babbitt having the small uniform grain structure, obviously, is greater. The large structure may be likened to an old-fashioned flagstone pavement which cracks up readily under certain loads and impacts, but if the stones are turned up on end, they will support loads many times greater. The fine and uniform babbitt grains correspond to the flagstones arranged on end.

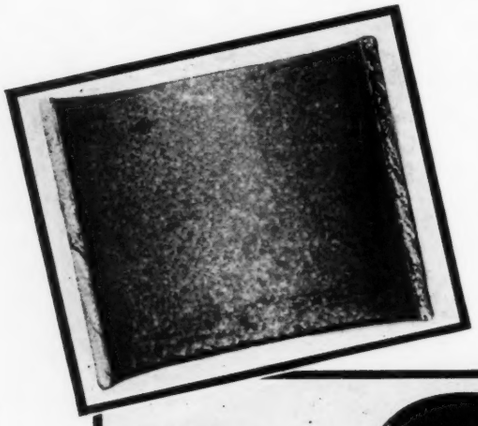


Fig. 2 — Etched surface of tin-base babbitt bearing showing satisfactory fineness and uniformity of grain

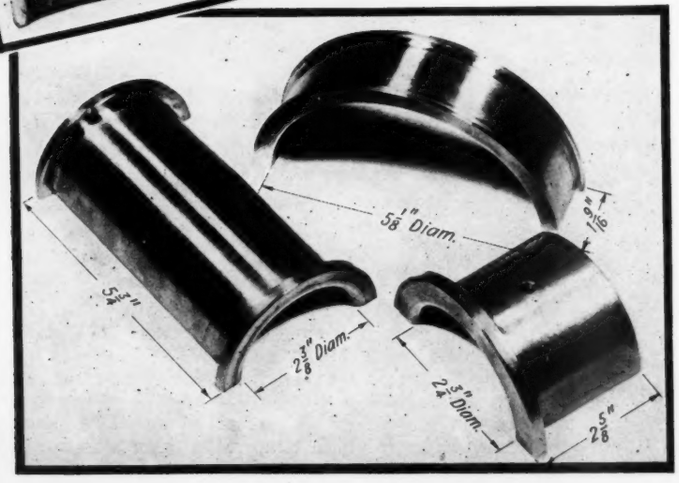


Fig. 3 — Diamond-bored precision bearings of leaded-bronze, used for special machine construction. The backs are ground and wall and flange thickness are finished to close tolerances

For many years tin-base babbitts were used almost universally for main and connecting-rod bearings in both passenger cars and commercial vehicle engines, but there was little difference in the types of engines. Today there are a wide variety of engine types of high speed or low speed, those with heavily loaded bearings, others with lighter loaded bearings; some having good lubrication, many with poor lubrication. Some have high temperatures, others low; some with soft crankshafts, others with hard; two cycle or four cycle. Following past history, the search has been for a universal bearing material, but apparently this ideal is becoming increasingly difficult of attainment. All indications point to the necessity of carefully selecting the proper bearing material for the individual engine.

Whenever bearing failures occur it seems to be rather common practice to point the finger of suspicion towards the bearing material or its bond. In many instances the

real cause has been overlooked, but a bearing material for higher duty usually helped the situation. A few such causes are as follows:

1. Insufficient thickness of the backing material, being particularly true in some of the very thin steel-backed bearings now in use.
2. Excessively thin lining of bearing material used in some of the thin steel-backed bearings.
3. Insufficient oil clearance.
4. Improper distribution of lubricant in the bearing. Some designers erroneously believe that when oil is introduced under pressure into a plain bearing from a hole in the crankshaft that the oil goes where it does the most good.
5. Excessively high operating temperatures.
6. Restriction in the oil channels particularly those to the connecting rod bearings.
7. Oil pumps of too small a capacity.

There is no doubt that better bearing materials will be demanded and supplied, but more careful attention to design features of the bearings and associated parts will result in more satisfactory and longer lived bearings.

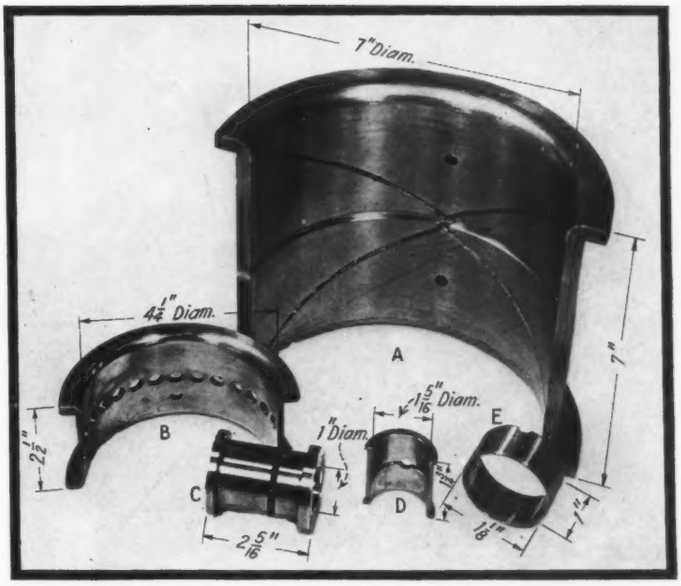


Fig. 4—Steel-backed bearings lined with various materials. (A) Cast steel back, lined and flanges faced with high-duty tin-base babbitt having same crystal structure as that in Fig. 2. (B) Cadmium-silver bearing sustains 2,900 lb. per sq. in. of projected area. (C) Full round flanged bearing shell is machined from bar stock, case hardened and lined with S.A.E. No. 11 babbitt. (E) High-lead babbitt is bonded to shell of welded steel tubing

Automotive Engine Bearings

A study of the history of main and crankpin bearings used in automotive engines, shows that decided improvements have been made in methods of bearing manufacture, types of bearing materials, control of processes, and standards of design which have resulted in important advantages to the engine and car manufacturer. Among them are:

1. Savings in assembly time, increased production and lowered costs in the engine plant.
2. A duplication of factory accuracy when service replacements are necessary.
3. The ability to stand up and render satisfactory service for longer periods under greater loads and speeds.

Increased production and lower assembly costs are obtained by the use of "precision" bearings for the crankshaft, connecting rod and cam bearing functions. Precision bearings are absolutely interchangeable in every respect, requiring no align-boring or reaming nor special fitting of any kind. They may be manufactured with either steel or bronze backs with the linings depending on the loads and speeds. The precision type is not only more accurate but also more satisfactory for service replacements as it is only necessary to remove a worn bearing or set of bearings and replace with new. If the shaft is in good condition and the replacement bearing has proper oil clearance, misalignments caused formerly by unskilled scraping and fitting are eliminated.

Features of the highly developed automotive engine bearings are applicable to all types of industrial machinery. In Fig. 3 is shown a group of precision, leaded-bronze bearings used in special machine construction. The backs are ground and the inside diameters are diamond bored. Wall thicknesses are held within a variation of 0.0005 in. and flange thicknesses within a variation of 0.002 in. In Fig. 4 is shown a group of precision steel-back bearings for various installations including car wheel, grinder spindle, gear tester and diesel crankpin. All of the bearings shown in Figs. 3 and 4 are assembled and used exactly as they come from the bearing manufacture and require no reaming, scraping, nor fitting.

Steel and bronze back precision or semi-precision bearings in sizes up to 4 in. in diameter seldom have a babbitt thickness more than $\frac{1}{32}$ in. Bearings as large as 11 in. diameter are successfully manufactured and used with a $\frac{1}{16}$ in. lining thickness. Dependable bonding of the lining material to the back is readily obtained and anchorages are unnecessary. The reduced amount of bearing metal required in these bearings effect a material saving.

The wide range of materials in which precision bearings are now obtainable are as follows:

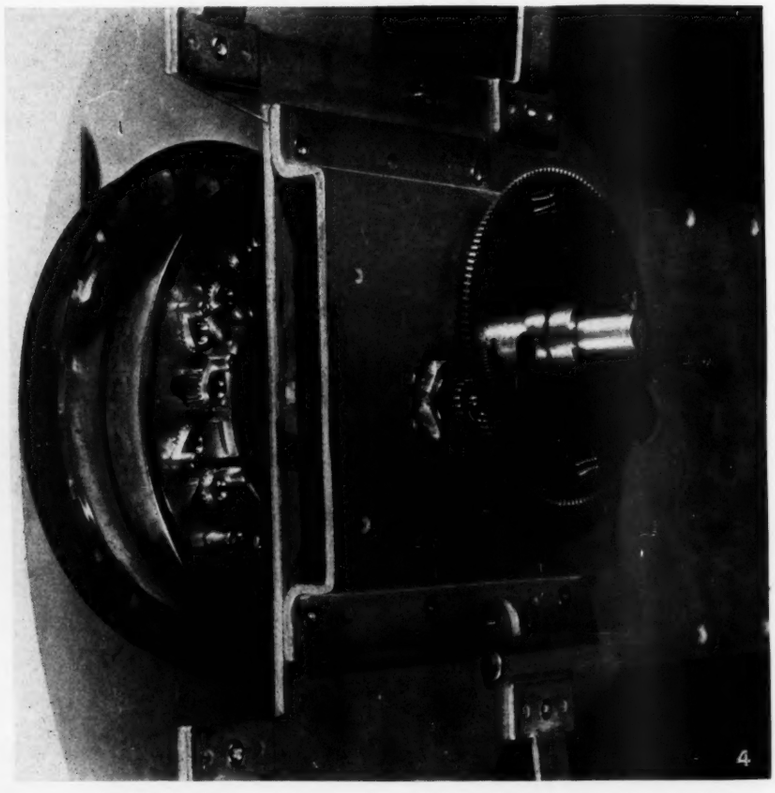
1. Tin-base babbitts, high-lead babbitt or cadmium-silver bonded to a steel back in either half shell bearings or full round, plain or flanged.
2. Tin-base or high-lead babbitt bonded to a bronze back in either half shell bearing or full round, plain or flanged.
3. Phosphor and leaded-bronze and many special bronze analyses. These materials are usually used in precision bearings when the bearing is made in halves. Full round bearings or bushings of these materials require that the I.D. be finished to size after assembly unless the bearing has a slip fit in its seat and is retained from turning by other means than a press fit.

The basic advantages of a precision bearing is that it may be used exactly as it comes from the bearing manufacturer, without align-boring or reaming or any other fitting operation after assembly. However, the use of such a bearing requires accuracy of machine work in all associated parts. The saddles or seats into which the bearings are assembled must be held to close dimensional tolerances, and must be truly round and free from taper.

Mechanism for Automatic Preset Tuning to Hairline Accuracy

1

Die-cast design make possible an economical device wherein any one of 19 stops can be adjusted independently for micrometer tuning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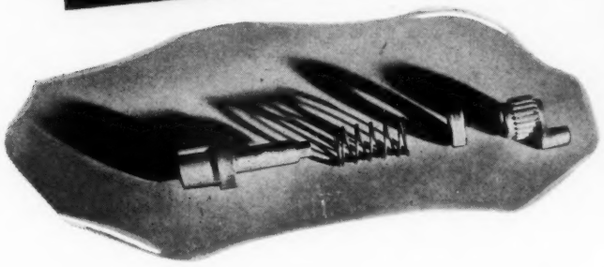
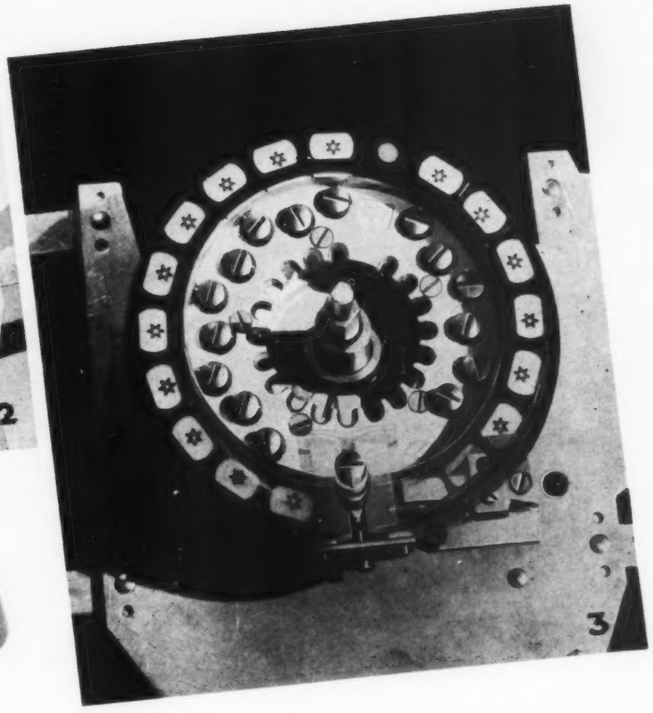
FOR quick and accurate radio tuning and to eliminate the possibility of poor station reception due to faulty tuning, Philco engineers developed a device whereby any one of 19 preselected stations can be tuned-in to hairline accuracy merely by turning a handle in either direction until it locks in position at a stop. The ingenuity of the design is the mechanism by which any one of the 19 stops can be adjusted independently for micrometer tuning. The illustrations show the construction of the mechanism.

A forked crank with a handle is mounted by means of two pins on a central hub which revolves freely on the main shaft. After the crank has been rotated to the station selected, the knob on the end of the crank is pressed in and a boss on the under side of the crank engages between two of the teeth on the inside of the dial body cover. Thus turning the crank turns the entire tuning unit.

Depressing the crank also depresses that one of the nineteen slotted-head plungers, shown in Fig. 2, which corresponds to the station selected. Each plunger has a dog at its opposite end. When the tuning crank depresses the plunger, this dog is pushed down,





causing it to project beyond the rear face of the dial body, in which position it remains while the crank revolves. When the crank reaches the lowest point on the dial, as shown in Fig. 3, the dog engages between two die cast strips which lock it in the correct setting for the particular station. When the crank handle is released it snaps back to its normal position, as does the dog and plunger unit, thereby freeing the dial for the next tuning.

As shown in the exploded view, the dog and plunger assembly is made up of a die-cast plunger with a single spline, slotted head and shaft—a steel spring—a brass collar and a die-cast dog serrated on its outer circumference. The shaft of the plunger and the hole through which the dog slides are cast with such accuracy that they make a press-fit assembly without machining.

When this assembly is depressed against the spring the brass collar remains stationary, resting against a shoulder in the dial body proper. When the handle is released the spring returns the assembly to its normal position. The shoulder on the plunger rests against the inner side of the dial body cover and thereby prevents the spring from forcing the assembly too far out in the front.

It is the serrated dog, however, that offers the most interest. The teeth on the dog fit into corresponding teeth in the dial body. Both sets of teeth are cast so accurately that, without machining, the dog slides back and forth freely, yet with no side play. Any play between these teeth would, of course, allow the offset operating lug of the dog to move and would thereby upset tuning precision.

In designing this device it was necessary to take into consideration the fact that different settings must be easily and quickly made. To do this, the set is accurately tuned manually to a station. The dial is then held firmly in that position and the stop plunger nearest the stop is depressed with a screw driver, pushing it down until the teeth on the dog clear those in the dial. The dog is then rotated until it locks between the two stops, each of which is hinged, the dog depressing the nearer stop against a spring as it rides up the sloping surface of the stop. Thus the two stops act as two latches. Releasing the pressure from the screw driver allows the teeth on the dog to re-engage with the teeth in the dial body. Thus a fixed dial setting is established for that particular dog. The call letters of the station are then written in the space provided next to the plunger.

Many precautions were taken to make the precision of this unit as lasting as possible. The larger spur gear, shown in Fig. 4, for example, is in reality two gears side by side, with four springs which tend to rotate the gears in opposite directions. When in mesh with the pinion, this arrangement eliminates back-lash and the possibility of play developing, through tooth wear.

A total of 45 zinc alloy die-castings are used in this device. Die-castings of zinc alloy were adopted because they offered the only means of making the unit strong enough without the cost being prohibitive. Great care had to be taken in the manufacture of the dies, for the castings must fit together with great accuracy in order to insure a smooth working unit.

A noteworthy feature of this device is an electric switch which cuts out reception when the crank is depressed. Thus the ripping noise of stations being passed as the dial is revolved is cut out. However, as soon as one of the stops has been depressed by the dog, reception is brought back in.

Indexing Drawings to Avoid Duplication

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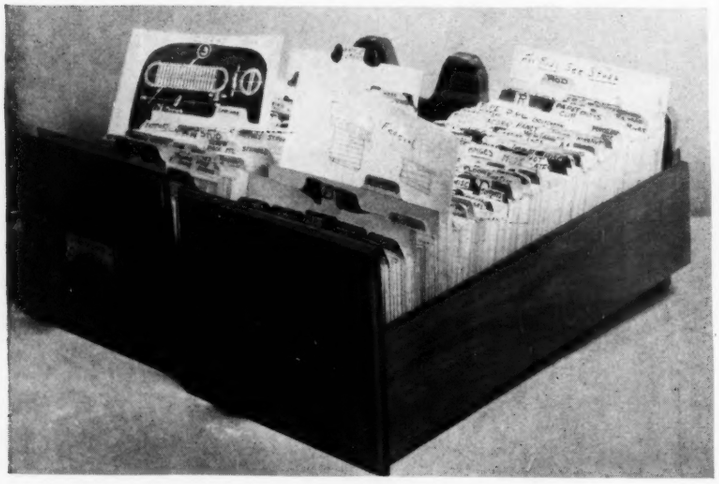
Westinghouse Electric & Manufacturing Company



Typical detail index. Guide cards such as "B" and "S" are red to indicate alphabetical divisions. The guide card "Waffle Irons" is blue to indicate parts common only to waffle irons

UNLESS there is a definite setup whereby drawing of similar parts can be located readily, many parts will be duplicated with inconsequential variations. In order to avoid such duplication, a detail index which lists all details and parts used should be established. In starting such an index, it is necessary to first index all old drawings.

One thing must be remembered. There are two types of details—first, those that will be common to two or more lines of products, and second, those that belong to only one line of product. Those coming under the first heading would include: screws, nuts, bolts, washers, springs, handles, contacts, terminals, etc. Those coming under the second head would include parts such as: range panels, sad iron covers, toaster frames, or in other words such parts as are used to build up the frame work of the product.

Plain white index cards and index guides, the size depending on the application, are used. A 4x6 card is a standard size that may be found convenient. It is also convenient to use a three-cut and a five-cut guide card, that is, three or five tabs to a set. Each tab should be lettered with a single letter of the alphabet, thus "A" would be the first card, "B" the second, and so on. To quickly distinguish guide cards from the other cards, they can be colored red and lettered in black with large bold face letters. Main divisions use three-cut guide cards, sub-divisions which would use five cut guides. These would be plain and simply lettered in black standard type letters.

As an illustration, under the letter "B" would be such divisions as, Bolts, Carriage, Hex.Hd., Sq. Hd. Tap, etc.—also Bushings, Buttons, Brushes and all other parts beginning with "B" that might be used on two or more types of products.

As an example of the index for standard parts used on one type of product, let us take a waffle iron. Such parts as the top, base, bottom covers, hinges and grid plates, common to waffle irons only, should be indexed under the letter "W" as Waffle Iron Parts, and they can also be sub-divided, with index guides of a different color, such as blue with black lettering.

The complete indexing of waffle iron parts includes the standard hardware items indexed under their respective letters, such as rivets under "R", screws under "S", nuts under "N", feet under "F" and so on, these parts being usable on other apparatus.

On the detail card is made a freehand sketch of the part, if it is a large part. If it is a small part, the detail is cut out a blueprint and pasted on the card. No attempt is made to have the scale or dimensions correct on this card, as that would involve a change on the index card each time the detail is changed. Also it would require a card for each detail, which would result in too many cards. On each card is also given a list of the detail drawings on which similar parts can be found. This will necessitate the user to refer to the detail drawing which will always be up-to-date and, at the same time, require the least amount of time to maintain the index.

This type of index fits in nicely with the tabulated drawing idea wherein lettered dimensions are given on the drawing and a table on the same sheet gives the corresponding numerical dimensions for many sizes and variations of the parts. The many different ways in which tabulated drawings can be made will depend upon the part itself—no definite rule can be set up. For example, one drawing may have as many as 200 thermal disks shown on it. They may be different in the number of holes in them or their temperature rating, but essentially are similar. By tabulating them, as many as 200 can be placed on one drawing; whereas if they were detailed separately, it would require some ten drawings of the same size to accommodate them.

Besides saving time, the index of tabulated drawings will prove its worth to the engineer or designer, in his being able to find and use an old part which may still be in stock or for which there may be a tool available. Another advantage in tabulated drawings is in the shop, as the tool department can see at a glance all the previous similar parts and can at times see if it is possible to use an old tool with only a slight modification.

Then, too, the tool designer will be able to compare the new part with old ones which are similar—thereby necessitating only slight changes in an existing tool. Also, the draftsmen can easily and quickly locate a drawing on which a similar part should be drawn. It is only by means of an index of drawings that it is possible to standardize parts properly.

PART II

Velocity and Acceleration Equations

Principles of Design for NON-CIRCULAR GEARS

J. J. PESQUEIRA

Discussion and development of expressions for angular velocity and acceleration relations and a method for obtaining a pair of rolling curves on rolling cones

AN EXPRESSION that proves that the angular velocities of rolling curves, at a given instant, are inversely proportional to their contact radii at that instant, is obtained by dividing Equation (6) by dt. Since $\omega' = d\theta'/dt$ and $\omega = d\theta/dt$, which are the angular velocities of L' and L, respectively about their centers of rotation, there results

$$r'\omega' = r\omega \tag{24}$$

If the equation of one of the curves L, is known, and is expressed by $r = f(\theta)$, and the angular velocity ω' of the other curve L' is to be determined in terms of the angular velocity ω and angular displacement θ of L, Equation (24) becomes by substituting $[q - f(\theta)]$ for r':

$$\omega' = \omega \frac{f(\theta)}{q - f(\theta)} \tag{25}$$

An identical result is obtained on differentiating Equation (9) with respect to time. Equation (25) is valid for any value of q. That is, it does not make any difference whether the curves are closed or open.

For the curves of Example II, Equation (25) gives

$$\omega' = \omega\left[\frac{r_0(2 - \cos\theta)}{q - r_0(2 - \cos\theta)}\right]$$

When a relation of the angular displacements of the curves is known, as by Equation (18), the angular velocities may be known before the curves have been determined; for, upon differentiating this equation once with respect to time, there results

$$\omega' = \omega F'(\theta) \tag{26}$$

where $F'(\theta)$ is the first derivative of $F(\theta)$

Since the angular velocities of two rolling curves are always proportional to each other, the angular velocities ω' of L' as a function of the angular displacements θ of L, may be written

$$\omega' = \omega G(\theta) \tag{27}$$

If $G(\theta)$ is known, the equations of the curves may be determined. They are of the general form

$$r = q\left[\frac{G(\theta)}{1 + G(\theta)}\right] \tag{28}$$

$$r' = \frac{q}{1 + G(\theta)} \tag{29}$$

$$\theta' = \int_0^\theta G(\theta)\, d\theta \tag{30}$$

These are derived as follows: Equation (27) may be written $d\theta' = G(\theta)\, d\theta$ by substituting $d\theta'/dt$ for ω' and $d\theta/dt$ for ω, and multiplying through by dt. The integral in Equation (30) is thus evident. Again, Equation (27) may be written $\omega'/\omega = r/r' = G(\theta) = r/(q - r) = (q - r')/r'$ from which the values of r and r' are obtained, as in Equations (28), (29), and (30), respectively. These results will be illustrated with an interesting example.

EXAMPLE V. When a conveyor chain made up of long links is driven by a sprocket wheel having few teeth and rotating at a uniform speed, the linear motion of the chain will be jerky. To remedy this, the sprocket wheel is made to rotate at varying angular speeds so as to impart substantially uniform linear motion to the chain. Fig. 6 shows an arrangement of conveyor chain and driving mechanism to accomplish this. A lobed gear L is mounted directly on the sprocket wheel shaft. The pinion L' is keyed to the driving shaft which rotates at constant angular velocity.

Assume that the chain has the point of tangency A, and the roller is at position A' distant from A any angle θ, the linear speed of the chain then is

$$v = a\omega\cos\theta \tag{E}$$

where a is the radius of the pitch circle of the sprocket wheel, and ω is its angular speed. If v is to be constant, ω must be inversely proportional to $\cos\theta$. Let L and L' engage each other externally, and be formed so as to fulfill Equation (E) and to keep v constant. Let P

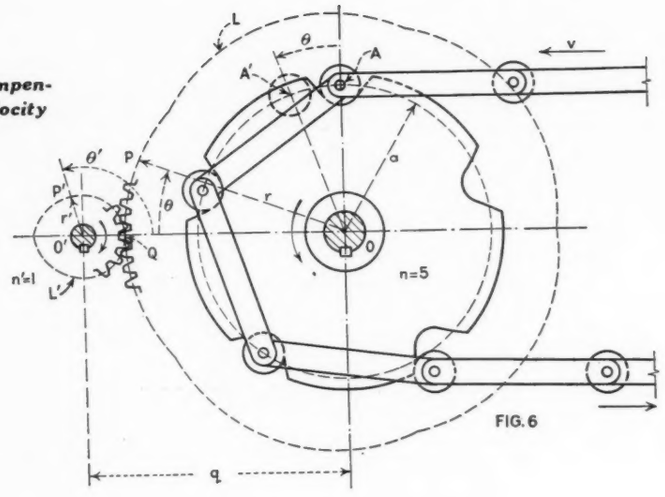


FIG. 6

Fig. 6—Conveyor chain sprocket with compensating gear drive for uniform chain velocity

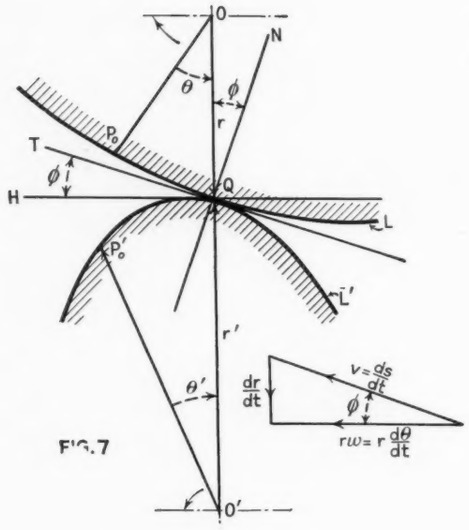


FIG. 7

Fig. 7—Determination of pitch line velocity at point of contact for use in calculating tooth strength by the Lewis formula

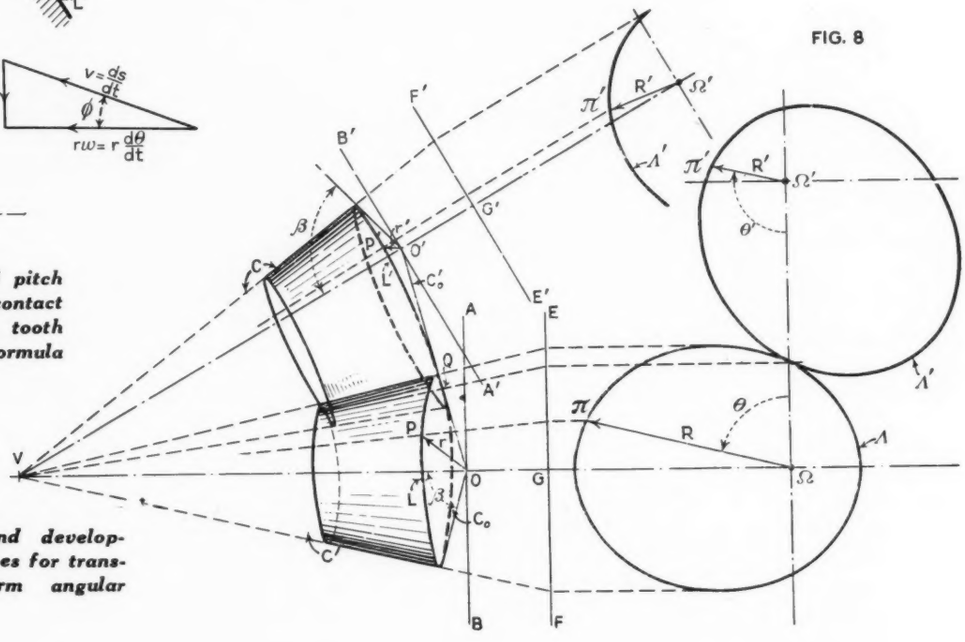


FIG. 8

Fig. 8—Layout and development of rolling cones for transmitting non-uniform angular velocity

and P' be two corresponding contact points in L and L' that will come into coincidence at Q through angles of displacement θ and θ', respectively, as one roller of the chain moves from A to A'. If ω' is the constant angular speed of L', Equation (E) may be written

$$\omega' = (a\omega\omega' \cos\theta)/v = \omega k \cos\theta = \omega G(\theta)$$

in which $k = a\omega'/v$. The equations of L and L' giving the coordinates of the points P and P' are, by Equations (28), (29), and (30),

$$r = q\left[\frac{k\cos\theta}{1 + k\cos\theta}\right] \qquad (F)$$

$$r' = \frac{q}{1 + k\cos\theta} \qquad (G)$$

$$\theta' = \int_0^\theta k\cos\theta d\theta = k\sin\theta \qquad (H)$$

Eliminating the parameter θ between the last equations then for L',

$$r' = \frac{q}{1 + \sqrt{k^2 - \theta'^2}} \qquad (J)$$

If n is the number of teeth in the sprocket wheel, the chain roller will engage the sprocket tooth when $\theta = -\pi/n$ and be carried over through an angle $2\pi/n$ where $\theta = \pi/n$; whereupon the succeeding roller will engage the next tooth. Hence L must be composed of n equal arcs whose shape is determined by Equation (F), in which θ is allowed to vary from $-\pi/n$ to π/n. L' may consist of a number n' of equal arcs joined together (as for L), whose shape is determined by Equations (H) *or* (J). By reasoning analogous to that followed in the deduction of Equation (15) for ordinary lobed curves, Equation (H) results in

$$\pi/n' = k\sin(\pi/n)$$

or

$$k = \pi/[n'\sin(\pi/n)]$$

With this value of k, the curves can now be determined by means of Equations (F) and (H), or (J), without regard to the quantities v, ω, ω'. In Fig. 6, the number of arcs in L is $n = 5$, and the number in L' is $n' = 1$.

It is to be noted that when n is even, the chain will recede from the sprocket wheel at uniform speed; but

when n is odd, the recession will be jerky. Also, when n is even, the sense in which the sprocket wheel turns is reversible, but not when n is odd.

The above curves represent the exact solution of the problem. In practice, however, approximate curves without sharp corners may be employed.

Since the velocity of the point of contact Q relative to the common tangent line of a pair of rotating curves L and L', Fig. 7 is

$$v = \frac{ds}{dt}$$

where ds is an element of arc of L of Q, and also since

$$ds = \sqrt{dr^2 + r^2\ d\theta^2}$$

it follows that

$$v = \sqrt{\left(\frac{dr}{dt}\right)^2 + r^2\ \omega^2}$$

in which $\omega = d\theta/dt$ is the angular velocity of L. Thus, v is the diagonal of a parallelogram having dr/dt and $r\omega$ as sides. The slope of v with respect to $r\omega$ is

$$\tan \phi = \frac{dr/dt}{r\omega} = \frac{dr/dt}{r\ (d\theta/dt)} = \frac{1}{r}\frac{dr}{d\theta} \qquad (31)$$

This shows that ϕ is precisely the angle that the tangent line QT makes with the line QH normal to the line of centers. The angle ϕ is the angle of obliquity of contact.

The tangential velocity can be expressed as

$$v = r\omega/\cos \phi \qquad (32)$$

As a factor v is used in the calculation of tooth strength in the Lewis formulas.

If the equation of one of the curves is $r = f(\theta)$,

$$\tan \phi = f'\theta/f\theta \qquad (31')$$

$$v = \omega \sqrt{f(\theta)^2 + f'(\theta)^2} \qquad (32')$$

where $f'(\theta)$ is the first derivative of $f(\theta)$.

The last formulas can be applied to the case of Example II where for one curve $f(\theta) = r_o\ (2 - \cos \theta)$, and $f'(\theta) = r_o \sin \theta$, and by Equations (31′) and (32′), respectively

$$\tan \phi = \frac{\sin \theta}{2 - \cos \theta}$$

$$v = \omega r_o \sqrt{5 - 4 \cos \theta}$$

The maximum angle of obliquity of contact here is $\phi =$ 45 deg., and if ω is constant, the maximum tangential velocity is $v = 3\omega r_o$ which occurs at the point $\theta =$ 180 deg.

Let $r = f(\theta)$ be the equation of one of a pair of rolling curves. The angular displacements of the two curves is then given by Equation (10). This differentiated twice with respect to time is

$$\frac{d^2\theta'}{dt^2} = \frac{f\theta}{[q - f(\theta)]}\frac{d^2\theta}{dt^2} + \frac{qf'(\theta)\ \omega^2}{[q - f(\theta)]^2}\left(\frac{d\theta}{dt}\right)^2$$

or

$$\alpha' = \frac{f(\theta)\ \alpha}{[q - f(\theta)]} + \frac{qf'(\theta)\ \omega^2}{[q - f(\theta)]^2} \qquad (33)$$

Here the angular accelerations α' of L' is composed of two terms, one of which is proportional to the angular accelerations α of L and the other proportional to the square of the angular speeds ω of the same curve L. In practice, one of the curves (that of the driving gear) is usually considered to rotate uniformly. In this case, if L rotates at a constant rate its acceleration is zero. Hence

$$\alpha' = \frac{qf'(\theta)\ \omega^2}{[q - f(\theta)]^2} \qquad (33')$$

$$\omega = \text{constant}$$

But if it is L' that rotates uniformly, then by Equation (33)

$$0 = \frac{f(\theta)\ \alpha}{[q - f(\theta)]} + \frac{qf'(\theta)\ \omega^2}{[q - f(\theta)]^2}$$

But, by Equation (25)

$$\omega = \frac{[q - f(\theta)]}{f(\theta)}\omega'$$

Hence, substituting this value in the preceeding equation and solving for α,

$$\alpha = \frac{qf'(\theta)\ [q - f(\theta)]}{f(\theta)^3}\omega'^2 \qquad (33'')$$

$$\omega' = \text{constant}$$

Referring to the curves of Example II, where for L

$r = r_0\ (2 - \cos \theta) = f(\theta)$. Therefore, $f'(\theta) = r_0 \sin \theta$.

If L rotates at a constant rate, the accelerations of L' will be, by (33′)

$$\alpha' = \frac{q\ r_0 \sin \theta}{[q - r_0\ (2 - \cos \theta)]^2}\omega^2$$

$$\omega = \text{constant}$$

On the other hand, if L' rotates uniformly, Equation (33″) gives for the acceleration of L

$$\alpha = -\frac{q \sin \theta\ [q - r_0\ (2 - \cos \theta)]}{r_0^2\ (2 - \cos \theta)^3}\omega'^2$$

$$\omega' = \text{constant}$$

If the angular displacements of the pair of rolling curves is related by the Equation $\theta' = F(\theta)$, then upon differentiating it twice with respect to time

$$\alpha' = F'(\theta)\ \alpha + F''(\theta)\ \omega^2 \qquad (34)$$

where $F'(\theta)$ and $F''(\theta)$ are the first and second derivatives of $F(\theta)$, respectively. If ω is constant,

$$\alpha' = F''(\theta)\ \omega^2 \qquad (34')$$

$$\omega = \text{constant}$$

But if ω' is constant, put

$$0 = F'(\theta)\ \alpha + F''(\theta)\ \omega^2$$

By Equation (26) $\omega = \omega'/F'(\theta)$. Substituting this value in the above equation and solving for α,

$$\alpha = -\frac{F''(\theta)}{F'(\theta)^3}\omega'^2 \qquad (34'')$$

$$\omega' = \text{constant}$$

When the angular speeds of a pair of rolling curves are connected by the relation $\omega' = \omega G(\theta)$, by differentiating once with respect to time,

$$\alpha' = G(\theta)\ \alpha + G'(\theta)\ \omega^2 \qquad (35)$$

When ω is constant

$$\alpha' = G'(\theta)\ \omega^2 \qquad (35')$$

When ω' is constant

$$\alpha = -\frac{G'(\theta)}{G(\theta)}\omega^2 = -\frac{G'(\theta)}{G(\theta)^3}\omega'^2 \qquad (35'')$$

To illustrate the last result, let us investigate the accelerations of the drive in Example V. Here, the angular speed ω' of the pinion L' is constant. Putting $G(\theta) = k \cos \theta$, then $G'(\theta) = -k \sin \theta$. Hence, Equation 35″ yields

$$a = \frac{\sin \theta}{k^2 \cos^3 \theta} \omega'^2$$

$$\omega' = \text{constant}$$

It is obvious that a steadily increases with θ, and will become infinite for $\theta = \pi/2$. However, θ varies only from $-\pi/n$ to π/n, where n must be greater than 2. The maximum possible acceleration of L will be attained, then, when the points joining the arcs in L cross the line of centers. It will be negative or positive as $\theta = -\pi/n$ or $+\pi/n$, but in either case, the absolute value will be the same. The maximum acceleration

$$a_{max} = \frac{\sin (\pi/n)}{k^2 \cos^3 (\pi/n)} \omega'^2$$

Since $k = \pi/[n' \sin (\pi/n)]$, then

$$a_{max} = \frac{n'^2 \omega'^2}{\pi^2} \tan^3 \left(\frac{\pi}{n}\right)$$

Conical Rolling Surfaces

In the preceding discussions the non-circular gears described are all planar. The general principles set forth apply to conical rolling surfaces also. The elements of the planar gear pitch surface are parallel to the axis. The elements of the conical gear pitch surface converge toward the point of intersection of the axes. When two rolling curves rotate on axes that intersect, both curves cannot be plane. A simple method for obtaining a pair of rolling curves on rolling cones is given here.

Let C and C', Fig. 8, be two rolling cones whose axes of rotation intersect at the vertices, V_1 at an angle a, and let O and O' be two points in the axes such that $VO = VO'$. Then, the intersections of C and C' with the circular cones C_0 and C_0' having vertices at O and O', respectively, and whose generatrices make the constant angle $\beta = (\pi - a)/2$ with the respective axes of rotation, will determine a pair of curves, L and L', that are mutually rolling curves. It is clear that the point of contact Q of the curves is always collinear with the points O and O'. Hence if P and P' are corresponding contact points in L and L', respectively, $OP + O'P' = OO'$ or

$$r + r' = q$$
$$\text{whence} \quad dr + dr' = 0 \qquad (N)$$

Here $r = OP$, $r' = O'P'$, and $q = OO'$. Evidently if ds and ds' are elements of arc at P and P'

$$ds' = ds \qquad (P)$$

With O as origin of cylindrical coordinates

$$ds^2 = \rho^2 d\theta + d\rho^2 + dz^2 \qquad (Q)$$

where ρ is the distance of P from the axis VO, θ is the dihedral angle between the planes VPO and OVO', and z is the distance of P from the plane AB, through O, normal to VO. Similarly

$$ds'^2 = \rho'^2 d\theta'^2 + d\rho'^2 + dz'^2 \qquad (Q')$$

where ρ' is the distance of P' from VO', θ' is the dihedral angle between the planes $VP'O'$ and OVO', and z' is the distance of P' from the plane $A'B'$, through O' normal to VO'. Putting in the following values of

$$\rho = r \sin \beta$$
$$\rho' = r' \sin \beta$$
$$z = r \cos \beta$$
$$z' = r' \cos \beta$$

there results

$$d\rho = \sin \beta \, dr$$
$$d\rho' = \sin \beta \, dr'$$
$$dz = \cos \beta \, dr$$
$$dz' = \cos \beta \, dr'$$

Substituting these values in (Q) and (Q') these equations become, respectively

$$ds^2 = r^2 \sin^2 \beta \, d\theta^2 + dr^2$$
$$ds'^2 = r'^2 \sin^2 \beta \, d\theta'^2 + dr'^2$$

Equating the second members of these equations and extracting square roots, noting that, by Equation (N), $dr'^2 = dr^2$

$$r d\theta = r' d\theta' \qquad (N')$$

Clearly, if two curves with intersecting axes of rotation satisfy Equations (N) and (N'), they are mutually rolling curves. Equations (N) and (N') are identical in form with Equations (5) and (6) for plane curves.

Let EF be a plane normally cutting VO at G, and let $VO = a$, $VG = b$. The plane EF will cut out of the cone C a plane curve Λ whose radius vector is

$$R = \frac{b}{a} \frac{r}{\sin \beta}$$

at an angle θ from the plane OVO'. Similarly, if the plane $E'F'$ cuts VO' normally at G', and $VO' = a$, $VG' = b$, this plane will cut out of the cone C' a plane curve Λ' whose radius vector is

$$R' = \frac{b}{a} \frac{r'}{\sin \beta}$$

at an angle θ' from the plane OVO'. The curves Λ and Λ' are clearly mutually rolling curves, since

$$dR + dR' = \frac{b}{a \sin \beta} (dr + dr') = 0$$

$$\text{and } r d\theta = \frac{a}{b} R \sin \beta \, d\theta, \; r' d\theta' = \frac{a}{b} R' \sin \beta \, d\theta'$$

which give

$$R d\theta = R' d\theta'$$

The distance between the centers of rotation Ω and Ω' of Λ, and Λ' is

$$R + R' = \frac{b \, q}{a \sin \beta} = 2 \, b \tan \tfrac{1}{2} \, \alpha$$

If in particular $b = a \sin \beta$, then

$$R = r, \; R' = r'$$
$$R + R' = q$$

From all that has preceded it follows that each curve in a pair of plane rolling curves is a section of one member in a pair of rolling cones with intersecting axes of rotation, the section being taken normally to the axis of rotation of the corresponding cone. The determination of rolling cones from plane rolling curves is thus evident. The pair of cones and the pair of plane curves will have identical angular kinematic properties.

Decorative Treatments for Molded Plastics

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Industrial Designer

Here are some general rules and specific means by which molded plastic parts can be made attractive at little or no expense. The relative costs of the molds are also discussed

ALMOST every engineer is called upon some time or other to design molded plastic parts. When the piece is to be a housing, cover, or other external element where appearance is important, he may find this job not easy because plastic materials have definite properties and limitations. What makes an attractive piece in one material, a plated stamping for example, will not necessarily make an attractive plastic molding. In black phenolic material, of which about three-quarters of all plastic moldings are made, the job is even harder, because a black undecorated phenolic piece has little surface interest of its own.

There are rules, however, that the designer can follow which will help him to achieve attractive molded parts. Perhaps the two most important rules are: (1) Don't consciously strive to be modern or modernistic by means of eye-tiring designs on the surface. (2) Strive for simplicity, remembering that a molded part, like a machine, is best when it is simple.

For specific rules, we can safely indulge ourselves in a generalization when we say: Avoid flat molded surfaces. Flat surfaces are inherently uninteresting in that they throw no highlights. Often flat surfaces seem to be called for, and often are the least expensive, but if appearance is important, curve the surface, even if only slightly, so you are sure of at least one highlight from any angle. You will find that the highlight emphasizes the luster and sleekness of the molding.

There are no general rules one can lay down on the contours of a molding, since contours are often largely dictated by its function, and unless an engineer has an inherent sense of proportion he should let the function dictate the shape, smoothing and simplifying it as much as possible.

Quite often, however, the engineer's inherent desire for simplicity in a molded part will be overcome by a feeling that his molding lacks interest or contrast, and then arrives the problem of surface decoration and how to approach it. This need is usually more apparent where fairly large flat surfaces are unavoidable and there is no opportunity for highlights or integral or attached parts to break up this surface. Also, unless special care is taken to avoid it, large flat moldings tend to show a slight waviness caused by the flow of the material in the mold, and perhaps also a slight orange peel effect. This is not noticeable as a rule on curves or cylindrical objects. Where flat surfaces cannot be avoided, it is often wise to use a surface treatment of some sort to minimize waviness or to achieve the needed contrast.

Decorative treatments can take many forms, and it is up to the designer to adapt the ones most appropriate and practical. Typical examples of these decorative techniques are shown in the accompanying illustrations.

Perhaps some of these techniques need a word of explanation. The first two are usually employed to achieve a series of concentrated highlights to contrast with a smooth undecorated surface. Or they may be used entirely to cover portions of a small object, as for instance, the fluting of all four sides of a check-writer housing.

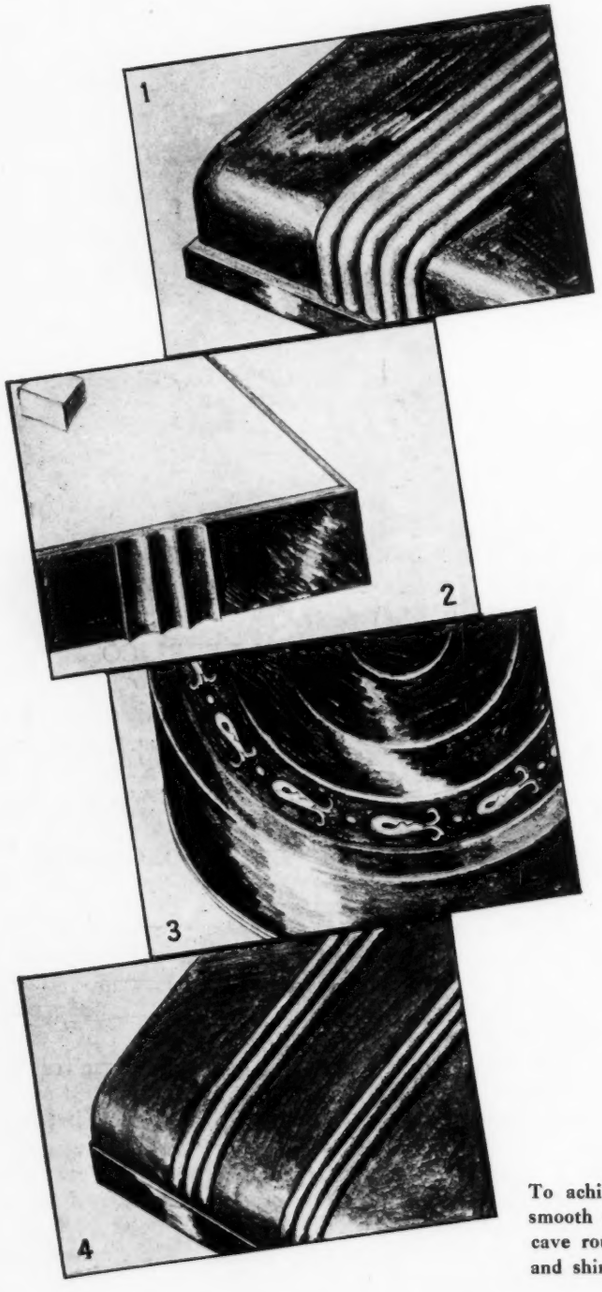
Relief engraving is a little more pretentious, in that it usually involves considerable hand-work in making the mold—unless entirely geometric—and consequently is more costly. Used judiciously, however, it can add considerably to the richness of a molded piece, but it should not be attempted by an untrained man.

Concentric shiny ribs or flutes in a series, or other relief engraving, thrown out in relief against a satin finished background is another method to achieve rich decorative treatment. It accentuates the luster of the surface and makes a practical finish for an article that will receive a great deal of handling. Wiped-in engraving, as with bas-relief engraving, cannot usually be employed to fullest advantage, except by an experienced man. In practice, the mold is engraved in such a way as to produce depressed lines in the molded piece which is subsequently painted with lacquer or pigment and wiped off, leaving the color only in the sharply-cut depressed design.

Other decorative methods include the control of highlights by using different planes or achieving a change of direction in a series of steps or set-backs, in which rounded edges on the steps will catch a stronger highlight and eliminate the feeling of too much jaggedness. One technique that offers possibilities is the combination of a bas-relief engraved surface on which lacquer has been daubed and buffed off before entirely dry, which leaves the color in the low spots only. Cream-colored pigment on a molded brown surface, for instance, makes a pleasing effect.

Finally, one of the most popular methods of achieving interest and contrast in molded parts is the use of contrasting metals, plated chromium, copper or gold, or the use of contrasting plastics to form the components of a molded piece. Often dull finished metal on a lustrous molded surface achieves a greater richness than when the metal is shiny.

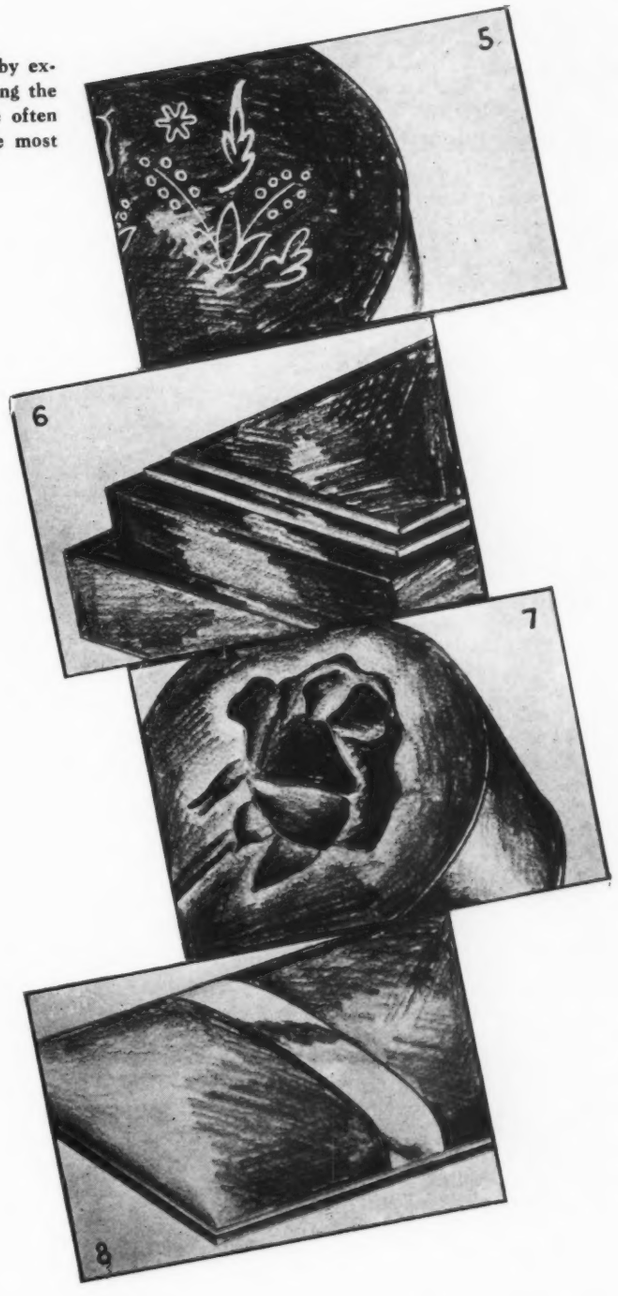
A word should be said here about the relative costs of molds involving these various decorative techniques. As most of us know, the dies used in molding plastic materials are made of a high carbon steel, either ground or machined with lathes and grinders, or hobbed to



DECORATIVE DESIGNS IN PLASTICS

To achieve a series of concentrated highlights to contrast with smooth undecorated surfaces, convex rounded ribbing (1) or concave rounded ribbing (2) are often used. Concentric ribbing (3) and shiny relief on satin-finish (4) can also be used.

Wiped-in engraving (5) cannot usually be employed except by experienced designers. A stronger effect can be gotten by buffing the wiped-in engraving (7). Steps, setbacks and panels (6) are often used for rectangular pieces. Metal inlays (8) is one of the most popular methods of getting rich contrast



the proper shape and polished. It naturally follows that the least expensive decorations are those that can be cut by a milling machine or shaper. Thus a series of ribs can easily be obtained on molded pieces by machining the surface of a mold, whereas an intricate design for a wiped-in engraving job requires hand labor. Fluting can sometimes be obtained by ordinary machining in the mold, depending upon the places used, but relief engraving on anything but a small surface must be done by hand in each cavity.

A recess in the molded piece to take an inlay of metal or sheet plastic such as cellulose acetate, can easily be machined, and satin finish on a mold can be obtained by sand blasting or by engraving fine grooves by machine. Of equal importance is the final polishing of a mold, and here some designs make polishing easy and others make it difficult. Sharp edges and projections require careful hand work in polishing, so that a rounded edge with a half-inch radius is a much easier polishing job than a sharp or small radius corner. Also beware of designing a piece wherein three plane surfaces come together to form a sharp point, since it is impossible to get a power polishing tool into the corner to polish this portion of the mold, and a smooth job is difficult.

On small plastic moldings the hobbing process of making duplicate mold cavities is used. This eliminates nearly all of the hand work in die-making—once the hob is completed, of course. Generally speaking, it is used most frequently where eight or ten or more duplicate cavities are needed. Also, molds for making such parts as camera cases, medium-sized shallow trays, or housings up to four or five inches in diameter are usually made this way. The method consists of machining a pattern of the molding in hard steel, and forcing the pattern into the die steel under about 50,000 lb. per sq.in. pressure, thus producing an exact duplicate of the pattern in negative form. This method permits much greater intricacy and decoration at little extra cost. It is evidently wise to find out how the molds are to be made before proceeding with the design of the part to be molded, as the die making method may make possible economical decorative effects, or make their cost prohibitive.

There is always the danger of decorating the surface of a molding to such an extent that it becomes a dust-catcher and fails to convey the feeling of efficiency, so important on mechanized objects. A feeling of restraint is vital here, and it is always safer to lean too far in the direction of simplicity than to overdo any design technique. When in doubt, don't decorate.

The present vogue for so-called streamlining can also be overdone, but all in all its effect on design trends has been healthy, especially for plastics. Molding material takes naturally to the smoothly curved contours. Flowing lines and the absence of violently decorated surfaces in well-designed modern pieces, increase a molding's inherently pleasing tactile impression. When "streamlining" a molding consists of smoothing off bumps, bosses, sharp corners and other excrescences and "tear-dropping" formerly jagged or bumpy shapes, then we believe in it.

Another method of achieving contrast in a molded piece is by the use of either wiped-in lettering or contrasting labels. Here again experience and training in decorative art is vital. Dozens of excellent engineering jobs have been spoiled by the fatal mistake of having the engineer step out of his province into that of the artist. Lettering is an art of its own, and few tool makers or engineers are qualified to do good typographical layout work. The extra cost of having a lettering job laid out by an experienced artist is slight, and makes a world of difference in the appearance of the finished piece.

QUESTION AND COMMENT

Adjustable Intermittent Motion for Turntable

A. C. WOODBURY
Bellerose, N. Y.

● A drive is required for a miniature circular stage having four sets mounted on a turntable, each set to be illuminated for 10 sec. and the stage then darkened for one sec. while the next set is being moved into position. The turntable is approximately 36 in. in diameter, the total weight of table and exhibits being about 75 lb. The timing of the mechanism is adjustable, so that the time of rest or of indexing or both can be altered after being set up.

Having decided upon the use of a Geneva stop mechanism, the necessary flexibility is incorporated by placing the actuating pin on a roller chain, the length of which can be readily changed to alter the ratio between the time of movement and time of rest. Referring to the accompanying figure a single special chain link *A* extends outwardly from the chain to carry the actuating pin and roller, and also extends inwardly to carry a second pin *B* which is concentric with the actuating sprocket during the time that the special link engages this sprocket. Pin *B* engages a bell-mouthed slot *C* at the end of which the pin pivots while the roller is performing the indexing operation, thus providing pivoting point during the indexing period.

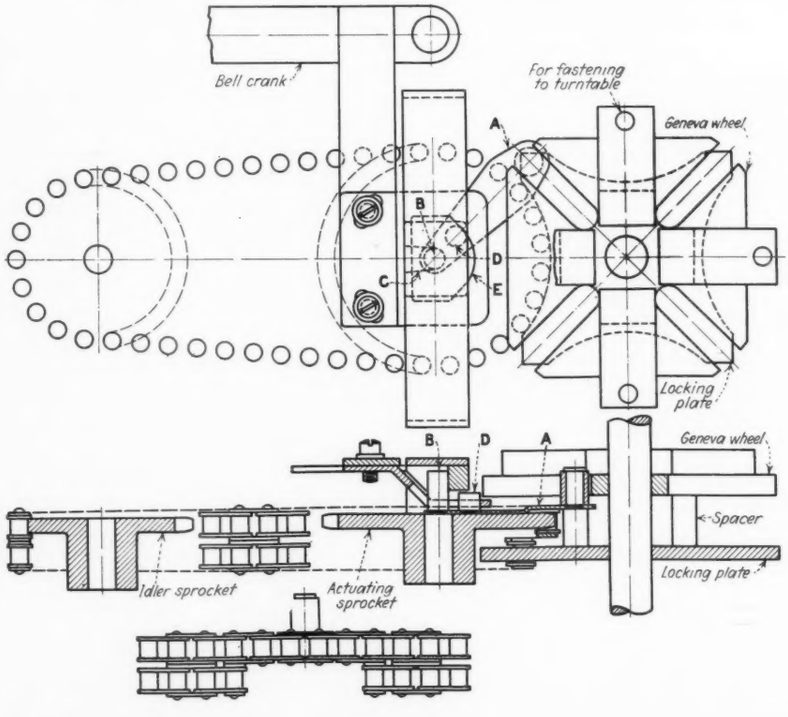
As shown in the plan view, the roller is entering a slot and has just reached the point where movement of the Geneva wheel begins. The turntable, centered on the vertical shaft passing through the Geneva wheel is accelerated during the next 45 deg. of sprocket movement and decelerated during the following 45 deg., being brought to rest as the roller emerges from the slot. The parts are shown midway of the motion in the sectional elevation.

To lock the mechanism during the rest period of the table, a locking plate is used, being secured to the indexing wheel with intervening spacers as shown in the elevation. The four sides of this locking plate are formed as shown by dotted lines in the plan view. The radius of each arc is equal to the pitch radius of the sprocket plus the radius of a chain roller, and each arc is struck from the center of the actuating sprocket. The ½-in. pitch chain is of double strand, the lower strand having one link omitted at each side of the actuating roller to avoid premature locking interference and to allow indexing movement at this time. Short pins and washers are used to complete the chain assembly as shown in the separate view of a portion of the chain. When in action, the last chain roller before the gap does not quite reach the center line through the sprocket and Geneva wheel before the actuating roller reaches the point of engagement. As the table movement ends the chain rollers cooperate with the actuating roller to bring the Geneva wheel to rest.

Single sprockets are used, the actuating sprocket having 24 teeth and the idler 18 teeth. The idler must be large enough so that the special link carrying the pivot pin will not interfere with the chain at the opposite side of the sprocket as it goes around the idler. The actuating sprocket is mounted on the vertical output shaft of a small gear reducer. Major speed changes in ratios up to 100 to 1 can be obtained by changing the gears in the gear reducer, and the minor changes are made by changing V-belt pulleys on the horizontal input shaft of the gear reducer and on the motor, the motor being adjustably positioned. These speed changes control the indexing time of the turntable. When this time is suitably adjusted the rest period can be made longer or shorter by changing the length of the chain, a long adjustment for the idler sprocket being provided for this purpose. The block in which the V- or bell-mouthed slot *C* for the pivot pin is cut is mounted on a horizontal strip at the sprocket center line. This strip must be long enough to reach beyond the path of the special chain link, it being bent down at the ends to attach to the sides of the gear reducer.

The light that illuminates the stage while it is at rest is controlled by a

Details of chain driven Geneva stop mechanism which is readily adjustable for length of dwell and speed of indexing



switch operated by a bell-crank, shown in both views. The lever is actuated by pin *D* on the special link of the chain which moves a cam *E* on the end of the bell-crank. The internally cut cam is made of a flat steel plate bent down close to the actuating link. The pivot pin *B* seats in the bottom of the V-slot *C* before the cam pin touches the cam. The length of contact of the light switch is controlled by an adjustable contact screw (not shown) on the end of the bell-crank and the time relative to the table movement is adjustable through the slotted attachment of the cam to its lever, as shown in the plan view.

Dimensions in Feet and in Inches

To the Editor:

● In the listing and billing of various machine parts, some companies seem to favor expressing lengths in inches, regardless of how great the lengths may be, while others are equally convinced that lengths should be expressed as feet and inches. The standard used in our plant, which manufactures road building machinery, requires the engineering department to express all lengths up to 6 ft. in inches while lengths greater than 6 ft. are expressed as feet and inches. The reason for this ruling is that all shop mechanics are supplied by the company, with flexible steel rules which roll up in a circular case. These rules are graduated in inches up to 72 in. It is therefore convenient for the shop man to read directly from drawing to the rule or vice versa in in. without the necessity of making any calculation or even for looking for the foot divisions on the rule. However, when the specified length exceeds 72 in. a calculation is necessary to convert inches into feet and inches. This system has been very successful.

—JOHN E. HYLER
Peoria, Ill.

[EDITOR'S NOTE: The American Standards Association has published standards for dimensioning, sponsored by the A.S.M.E. and Society for the Promotion of Engineering Education. Regarding expressing dimensions in feet and inches: "Dimensions up to and including 72 in. should preferably be expressed in inches and those greater than this length, in feet and inches. On structural drawings all dimensions of 12 in. or more should be expressed in feet, and inches. In automotive, locomotive, sheet metal and other practices all dimensions are specified in inches. When all dimensions are given in inches the symbol (″) is preferably omitted and a note may be placed on the drawing stating that all dimensions are given in inches. The symbol (′) is used for feet. When dimensions are in ft. and in. they should be hyphenated, thus 7′-0¾″. Copies of "Drawings and Drafting Room Practice" from which the above has been abstracted, are obtainable from American Standards Association, 29 West 39th St., New York, N. Y., at 50 cents per copy.

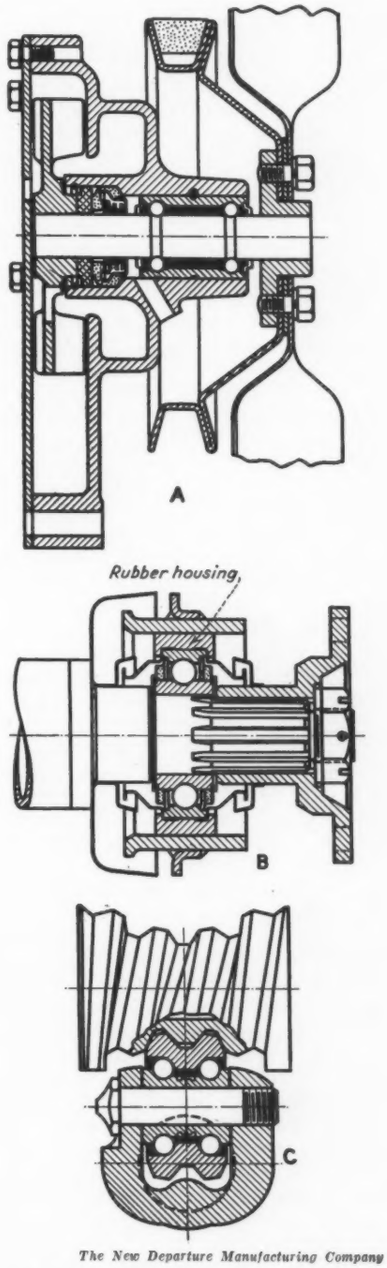
Unusual Bearing Applications in 1937 Automobiles

● Among the mechanical refinements in some of the 1937 automobiles recently exhibited is the increasing use of specially designed ball bearings wherein, the inner or outer races are cut in the shaft or the housing, the corresponding race rings being omitted. As shown (*A*) in the accompanying illustration, the inner race of a unit fan and pump shaft bearing is in the shaft itself. The fan and V-belt pulley are mounted on the short end of the shaft, the belt load being applied near the center of the bearing. The pump impeller is mounted on the other end. The wide space between the two rows of balls is sufficient for an ample supply of lubricant, making it unnecessary to add grease for the life of the unit. This lubricant is retained by permanent seals built into each end of the outer race of the bearing. There is really nothing fundamentally new in such bearings since their first application, ball bearings in bicycles use the wheel hub for the outer race and the axle for the inner race.

By eliminating the customary inner ring, it is possible to keep the O. D. of the bearing comparatively small. The one-diameter outer race is retained in the pump housing by a tangentially placed pin engaging a semicircular groove in the bearing. By pressing the fan and impeller on the shaft, threads, nuts, pins, keys and keyways have been eliminated. Bearing closure caps or lubricating fixtures are not required.

To drop the level of the car floor several inches but still avoid a tunnel or housing for the propeller shaft, one car now uses a two-piece shaft with three universal joints. This requires an intermediate support as shown at (*B*), for which a completely sealed ball bearing is used. The bearing is housed in rubber to make it self-aligning and insulate noise. Pressed steel slingers are also incorporated in the bearing assembly for protection against dirt and water.

For greater ease of steering and handling the car, the steering gear follower is mounted on pre-loaded ball bearings as shown at (*C*) in the illus-



The New Departure Manufacturing Company

Special forms of ball bearings used in 1937 automobiles. (A) Permanently lubricated fan and pump shaft bearing assembly. (B) Bearing mounted in rubber. (C) Double-tooth steering gear follower

tration. Two heavy teeth are formed on the outer ring, meshing and rolling with the "hour-glass" worm. The inner ring of the bearing is made in two parts, the abutting faces being so ground that when clamped tightly together by the bolt in the pitman arm, the bearing is preloaded for maximum rigidity. As in conventional practice, the whole assembly is submerged in oil.

For an Improved Patent System

To the Editor:

● On November 23 there was a celebration held in Washington, D. C., to commemorate the 100th anniversary of the U. S. Patent Office. I did not read all of the details of this celebration, but I assume that all of the speeches followed along the same lines as those that I read.

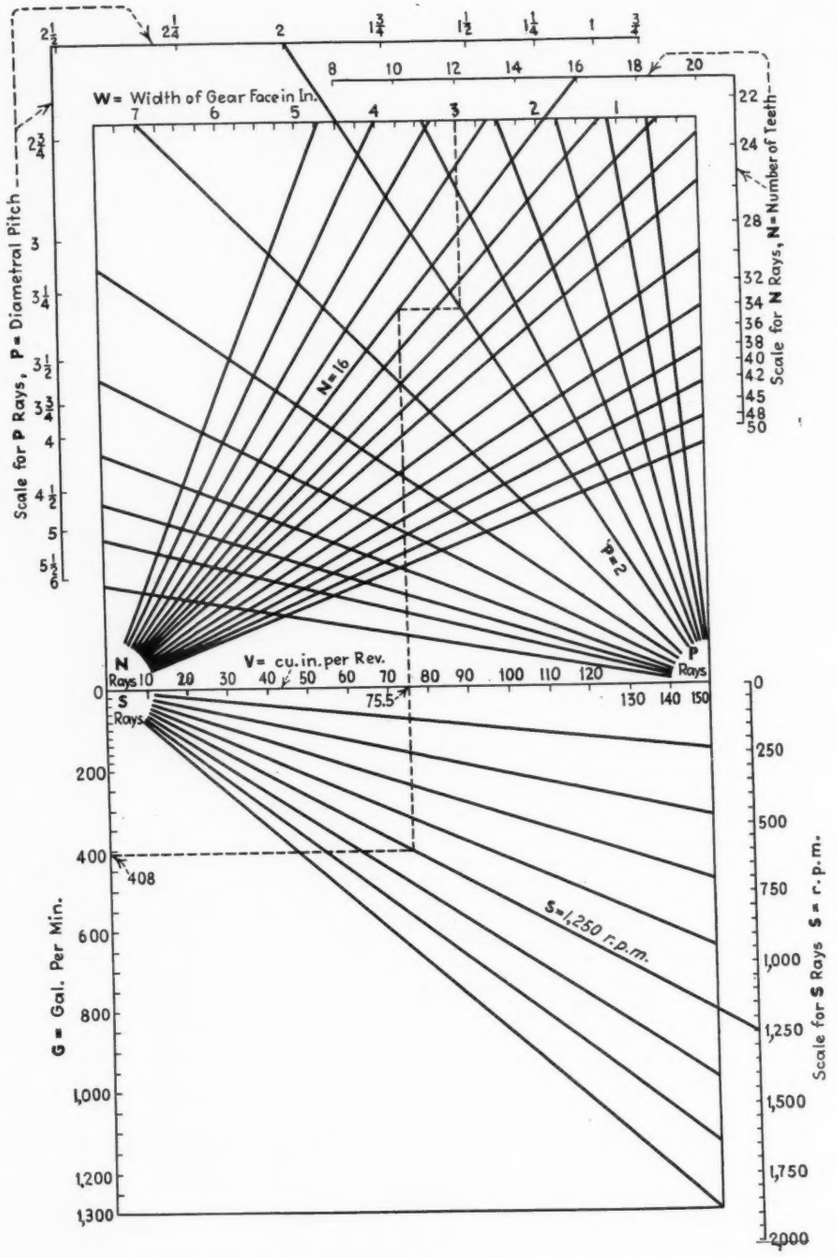
Of course it was only proper that all speeches should have been of a laudatory nature. Any other kind would have been out of place. And it is true that our patent laws, in spite of the many shortcomings, have done a lot to spur inventive genius. Many men, including quite a few speakers at the celebration, have benefited from the protection given by our patent system. The question is, can the system be improved, and if so, how?

One often hears of inventors who have been cheated out of their invention. And it is only natural that a company should attempt to circumvent a patent rather than purchase it. Of course, legislation cannot make good business men out of inventors or otherwise assure them a handsome return for their inventions. Nor can the patent system prevent ways and means of circumventing patents. As a matter of fact, many notable inventions were the results of attempts to circumvent patents. Watt's sun and planet wheel to avoid the crank patent is a historical example.

There is, however, one thing that might be done to clarify the patent situation. That would be to devise some procedure by which to prevent the patenting of worthless impractical devices. The harm in such patents is that although they are worthless devices they may contain some claims that prevent the patenting of a really valuable invention. Furthermore, these worthless patents simply clutter up the Patent Office and thereby impede progress and add to the cost of searches and investigations.

Perhaps other readers have more definite ideas on this subject. And perhaps there is something really being done about this question. I would be interested in the ideas and experiences of others.

—FRANK HOWARD
New York, N. Y.


W = Width of Gear Face in In.
Scale for P Rays, P = Diametral Pitch
Scale for N Rays, N = Number of Teeth
N = 16
P = 2
V = cu. in. per Rev.
N Rays
P Rays
S Rays
75.5
G = Gal. Per Min.
408
S = 1,250 r.p.m.
Scale for S Rays S = r.p.m.

Radial chart for finding discharge of gear pump in gal. per min. and displacement in cu. in. per revolution

Discharge of Gear Pumps

CARL P. NACHOD
Louisville, Ky.

● In the September 1936 number of *Product Engineering* J. J. Pesqiera gives a formula for gear pumps as follows:

$$V = \frac{2\pi W N}{P^2}$$

in which

V=volume per rev. in cu. in.
W=width of face of gear in in.
N=number of teeth in one gear
P=diametral pitch

This equation gives the approximate discharge per revolution, since the slip is disregarded, and the solution of it for various values of P, W and N can be obtained from the upper part of the accompanying radial chart. A second chart has been added below, to give the discharge in gal. per min. at various speeds, according to the equation $G = VS/231$ in which S is the speed in r.p.m. and G the discharge in gal. per min.

As an illustration of the use of the chart, the dotted line shows that a pump having a gear with a 3 in. face, 2 diametral pitch and 16 teeth, will deliver 408 gal. per min. at a speed

of 1,250 r.p.m. The dotted line cuts the V-scale at 75.5 cu. in., which is the discharge per rev., if the figure for this quantity is required. It will be evident that the rays for P are used in connection with the scale for W; and the rays for N, with the scale for V. If the value of V is not needed, the N-rays are used directly with the rays for S, the speed.

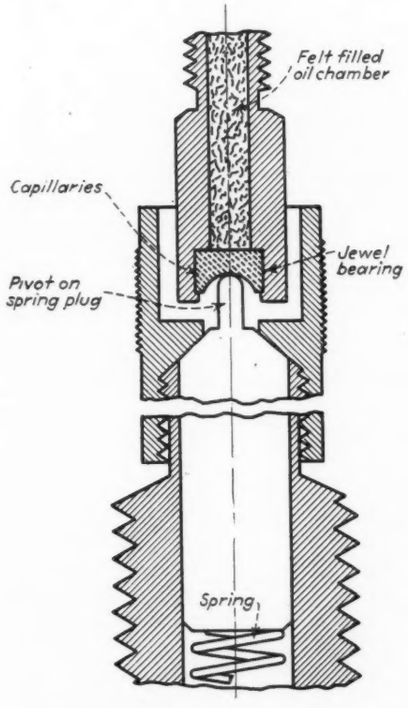
Since a multitude of rays confuses the chart, only a few have been drawn, but scales for the various rays are shown outside the chart for each bundle of rays, so that any required ray may be readily drawn in by the user of the chart.

Self-Lubricating Bearing

To the Editor:

● On page 313 of the August number of *Product Engineering* A. M. Holland inquires about a non-metallic, self-lubricating bearing. While the bearing shown in the accompanying illustration may not be the type that he has in mind, nevertheless it will be of interest, especially to designers of instruments. Because of the tremendous pressure on the point of such bearings, in many instances more than 100 tons per sq. in., the bearing must be so designed that a constant film of oil be maintained between the spring-backed pivot and the jewel. If the oil supply is too great the lubricant may become gummy, thereby causing too much friction in the bearing.

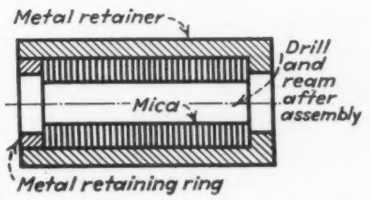
The assembly shown is used as the lower bearing in watthour meters. Above the synthetic sapphire bearing is a reservoir which is filled with oil-soaked felt. Lubrication is accomplished by means of capillary action, the oil seeping down the sides of the jewel and upwards to the pivot bearing surface. The jewel is in an inverted position so that impurities cannot collect to cause abrasion at the bearing point. In operation, because of the side thrust of the meter, the pivot point describes a constant minute circular motion in the jewel cup. This is said to be an improvement over conventional practice where the pivot point bears on one point in the jewel with the possibility of breaking the oil film and causing wear.—H. D. STEEL
Philadelphia, Pa.



Jewel bearing cup, lubricated by capillary action with filtered oil from reservoir above, is inverted to avoid possibility of impurities causing abrasion at bearing surface

To the Editor:

● Relative to the inquiry of A. M. Holland for a self-lubricating, non-metallic bearing, a patented type made up of laminated mica compressed into a metallic retainer, has given satisfactory results on certain applications. Although the bearing shown is not completely oilless, a ½-in. diameter



Bearing built up of laminated mica inclosed in a metallic retainer

bearing requires only two drops of oil every 8 hr. even when the journal is not hardened. In this application, a 28-lb. flywheel, driven by a single V-belt, was mounted at one end of the shaft, neither the flywheel nor the pulley being balanced. The running fit in the bearing was close and high temperatures were recorded without any indication of "grab," or scoring of the shaft. The construction of this bearing is of such a nature that the shaft is electrically insulated from its supports and can also be used where chemicals are present.

Plans are now in progress to put grease between the laminations when the bearing is being made, to make oiling unnecessary. —E. R. CHILCOTT
Technical Product Company

Can You Work This One?

H. E. SMITH
Newark, N. J.

[*Editor's Note:* Each month will be presented a simple problem that can be solved by logical reasoning, simple arithmetic or elementary algebra, but difficult to solve in that it will require a careful analysis to establish the method of solution. No "catch" problems or problems impossible to solve will be presented. A solution to the problem will be given in the next following issue. It is not expected that each problem will be new to every reader, nor will all of them be of a technical nature. They will be selected primarily on the basis of their value as intriguing problems that sharpen the wits.]

HOW MUCH MONEY HAD EACH?—Five beggars sat down in a circle and each piled up in a heap before him the pennies he had received that day—and the five heaps were equal. Then spoke the eldest and wisest of them, unfolding, as he spoke, an empty sack. "My friends, let me teach you a pretty little game! First, I name myself 'Number One,' my left-hand neighbor 'Number Two,' and so on to 'Number Five'. I then pour into this sack the whole of my earnings for the day, and hand it to him who sits next but one on my left, that is, 'Number Three'. His part in the game is to take out of it, and give to his two neighbors, so many pennies as represent their names that is, he must give four to 'Number Four' and two to 'Number Two'. He must then put into the sack half as much as it contained when he received it; and he must then hand it on just as I did, that is, he must hand it to him who sits next but one on his left—who will, of course, be 'Number Five.' He must proceed in the same way, and hand it on to 'Number Two', from whom the sack will find its way to 'Number Four' and so on to me again. If any player cannot furnish, from his own heap, the whole of what he has to put into the sack, he is at liberty to draw upon any of the other heaps, except mine!"

The other beggars entered into the game with much enthusiasm; and in due time the sack was returned to 'Number One', who put into it the two pennies he had received during the game, and carefully tied up the mouth of it with a string. Then remarking "it is a very pretty little game," he rose to his feet, and hastily left the spot. The other four beggars gazed at each other with rueful countenances. Not one of them had a penny left!

How much had each at first?

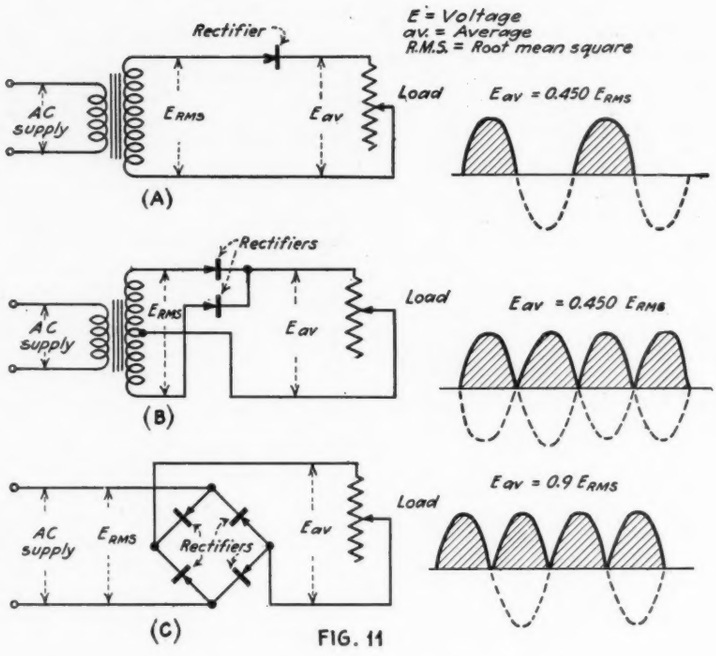


FIG. 11

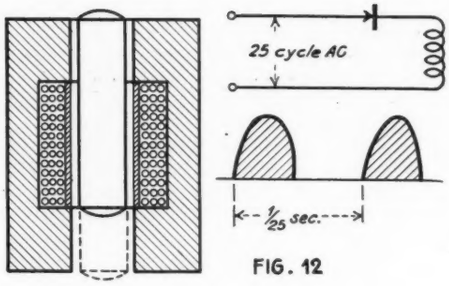


FIG. 12

Methods of

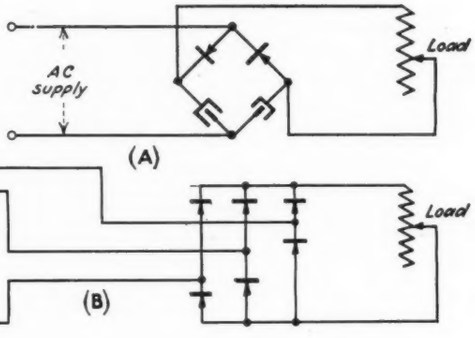


FIG. 13

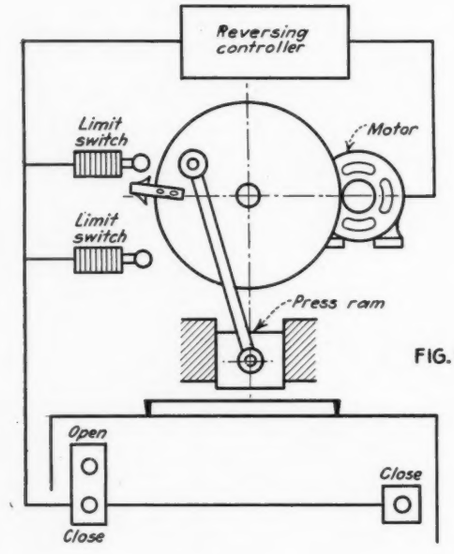


FIG. 15

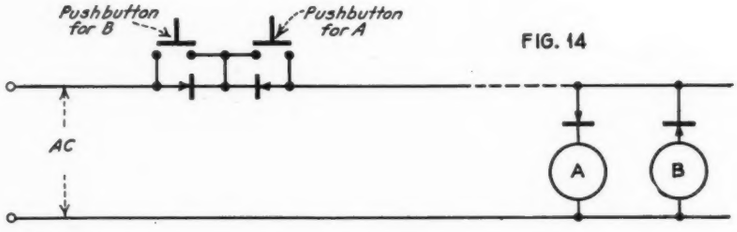


FIG. 14

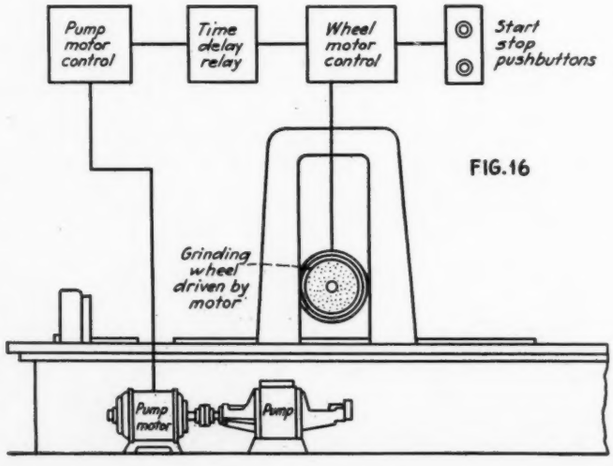


FIG. 16

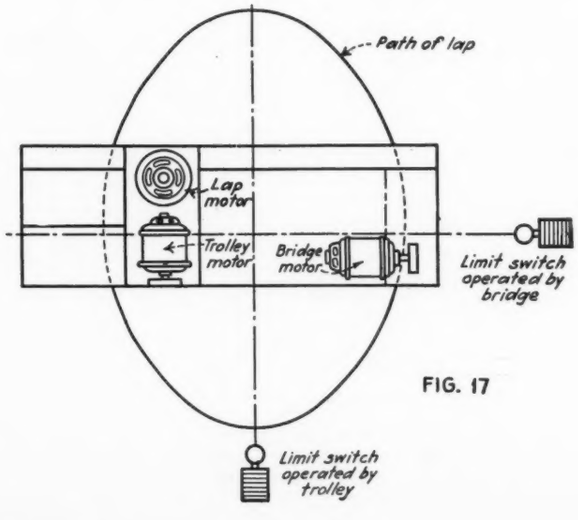


FIG. 17

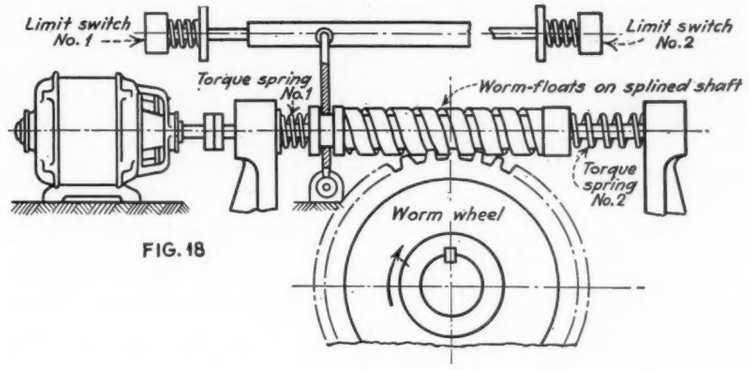


FIG. 18

Electric Control–II

R. S. ELBERTY, JR.
Machinery Electrification Division
Westinghouse Electric & Manufacturing Company

Fig. 11—Single-phase rectifier circuits generally used. (*A*) Half-wave rectifier circuit used in radio, also in industrial equipment such as vibrating machinery or electric razors, requiring reciprocating motion. (*B*) Full-wave rectifier circuit used in radio work and magnetic chucks. (*C*) Full-wave rectifier circuit used in industrial applications to obtain d.c. from a.c. source.

Fig. 12—Showing the use of a pulsating d.c. on a vibrating machine. In most instances, frequency of pulsations is important and on hammer shown, 25 cycle a.c. is used with a single-wave rectifier.

Fig. 13—Other rectifier circuits. (*A*) Single-phase voltage-doubler rectifier circuit used in radio work to obtain higher than line voltage without transformer. (*B*) A 3-phase, full-wave rectifier circuit, one type of rectifier used to obtain a large amount of d.c. power for power circuit.

Fig. 14—Illustrating the use of rectifiers in conjunction with magnetic control equipment on relays. Through the use of a rectifier in conjunction with d.c. relay, multiple control can be obtained over a single control circuit.

Fig. 15—Motor-operated press with safety control requiring operator to use both hands to start press. In starting, if either "close" button is released, the motor stops. To guard against blocking in one close button, the control is wired so that both close buttons must be fully released or press will not operate. Limit switches are used.

Fig. 16—Large grinders use pumps driven by separate motors. Pump motor need not be in operation when grinding wheel is not running but it is sometimes desirable to allow wheel motor to coast to rest before shutting down pump motor. This can be done electrically by means of time delay relay to permit pump motor to operate for predetermined time after wheel motor is shut down. For the starting sequence, an arrangement similar to that in Fig. 19 may be used.

Fig. 17—In a machine for polishing telescope mirrors, an elliptical motion of the polishing lap is sometimes required. Controls are arranged to reverse bridge motor at center of trolley motion; and to reverse trolley motor at center of bridge motion.

Fig. 18—Combination mechanical and electrical torque or load limiting device for control of motor-operated valves, chucks and clamps. When load becomes sufficiently high to stall wormwheel, the worm sliding on a splined shaft moves axially, similarly to a screw threading through a nut. This movement compresses a calibrated torque spring and opens a limit switch, thereby shutting off the motor.

Fig. 19—Electrical interlocking or sequencing of motors for large milling machine insures that coolant pump motor is running and pressure obtained before spindle motor starts, and that spindle motor is running before feed motor can be started. A master "stop" button dominates all controls.

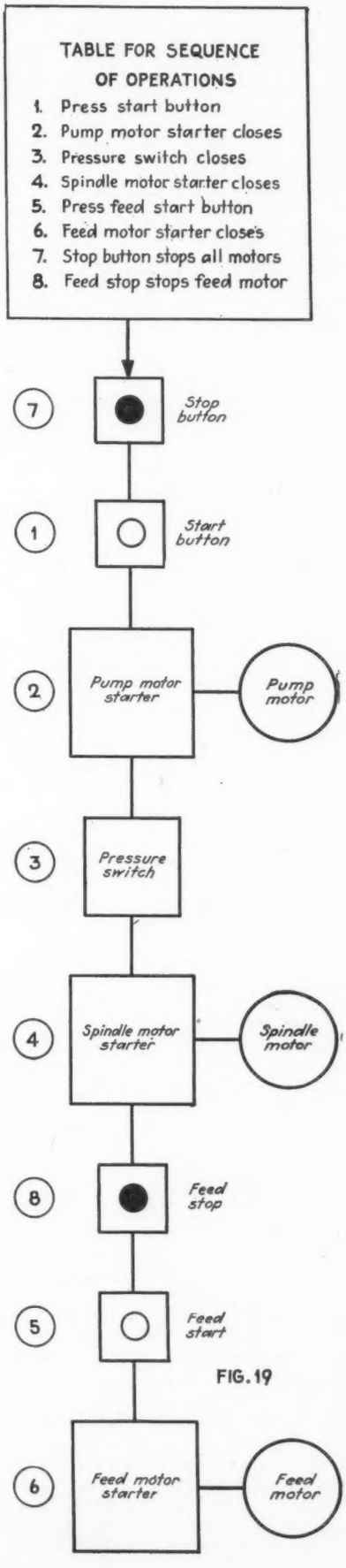


FIG. 19

NEWS

Prominent Engineers Honored by A.S.M.E.

THREE events at which honors were bestowed on engineers, marked the high points in the crowded program of the annual meeting of the American Society of Mechanical Engineers. The large ballroom of the Hotel Astor was filled to overcrowding by the many who attended the annual dinner on the evening of Dec. 2, at which Ambrose Swasey was awarded the Herbert Hoover Medal and also received the medal of the V.D.I., the German national engineering Society. On the previous day an equally enthusiastic crowd attended the Westinghouse 90th Anniversary Commemoration at which friends and business associates of the late George Westinghouse paid glowing tribute to this pioneer in several fields of engineering developments. And finally, there was "Honors Night" at which five members of the Society received awards in recognition of outstanding accomplishments.

At the annual dinner Gano Dunn made the citation for the Herbert Hoover Medal Board. In his brief citation, Gano Dunn reviewed the life and work of Ambrose Swasey, founder and chairman of the Warner & Swasey Company, pointing out the great pioneering work and distinguished service that Mr. Swasey had done in the development of machine tools and the making of telescopes. The rousing ovation when Ambrose Swasey arose to make his brief acceptance of this great honor bestowed upon "a fellow engineer for distinguished service," gave striking evidence of the high esteem in which this 90-year old pioneer in the engineering profession is held. Former President Herbert Hoover supplemented the remarks of Gano Dunn in paying tribute to Ambrose Swasey.

At the Westinghouse 90th Anniversary Commemoration on Dec. 1, W. L. Batt, retiring A.S.M.E. president, presided at the afternoon session during which Charles F. Scott, professor emeritus of electrical engineering at Yale University, extolled his old associate, George Westinghouse. The historic event in 1886 when the first comprehensive test on air brakes was made, was described by W. W. Nichols, now assistant to the president of Allis-Chalmers Manufacturing Company, who witnessed the tests as engineer of the Chicago, Burlington & Quincy Railroad. Mr. Nichols was introduced by Ralph Budd, president of the Burlington. Others who related experiences from their association with George Westinghouse, included Thomas Campbell, who has been employed in Westinghouse foundries for the past 51 years; A. W. Berresford, W. N. Storer and L. B. Stillwell, consulting engineers who played an important part in Westinghouse history; Frank W. Smith, president of Consolidated Edison Company; and C. R. Beardsley.

The evening session of the Westinghouse Anniversary Commemoration was called Honors Night at which session five prominent A.S.M.E. members were awarded various honors.

George A. Orrok received honorable membership for his outstanding contributions to the generation of power.

Edward Bausch, Bausch & Lomb Optical Company, was awarded the A.S.M.E. medal for "Meritorious mechanical developments in the field of optics."

Charles M. Allen, professor at the Worcester Polytechnic Institute, was awarded the Worcester Reed Memorial Medal for "his continued hydraulic laboratory work and for the permanent value of the papers on his development of methods of testing large hydraulic turbine installations."

H. A. Stevens Howarth, of the Kingsbury Machine Works was awarded the Melville medal for his paper "The Loading and Friction of Thrust and Journal Bearings with Perfect Lubrication."

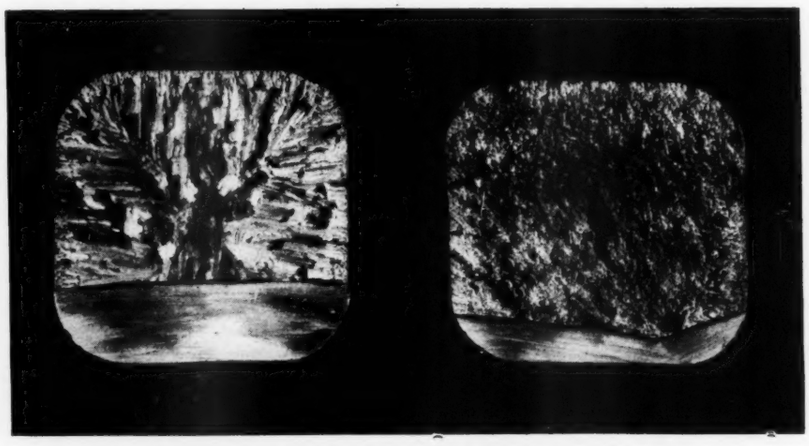
Harwood F. Mullikin, Jr., was awarded the Junior Award for his paper "Evaluation of Effective Radiant Heating Surface and Application of the Stefen-Boltzman Law to Heat Absorption in Boiler Furnaces."

For a review of the numerous papers that were presented at the many technical sessions, the reader is referred to the publications of the American Society of Mechanical Engineers.

Metallurgists Review Modified Steel Alloys

CERTAIN modifications of analysis, such as new gradations of the chromium content and suitable additions of other elements, are making many of the chromium steels more valuable, more economical and more widely applicable, according to metallurgists of the Electro-metallurgical Company in their annual review.

Included among the modifications of the widely used chromium steels is a molybdenum-bearing 9 per cent chromium steel suitable for severe service in petroleum refineries and power plants. For high-pressure service, where resistance to shock and the carburizing effects of hydrogen at high temperature are required, good results have been obtained with a 1.50 to 2.50 chromium steel with the addition of molybdenum and vanadium. Another modification is the columbium-bearing 2 per cent chromium steel, while the 4 to 6 per cent chromium steels have been improved by the addition of tungsten or molyb-



Photomicrograph of specimen showing the effect of nitrogen addition to 20 per cent chromium steel. At the left is a sample of the steel without the addition of nitrogen, and right is a specimen wherein nitrogen has been added

denum, whereby their creep strengths have been increased 4 to 6 per cent.

Among the important modifications of the straight chromium, oxidation-resistant steels is a new heat-treatable alloy containing 16 per cent chromium and 1 per cent nickel. This corrosion-resistance alloy, used in airplane construction, is heat-treated after fabrication. Another new alloy, containing 35 per cent chromium and 7 per cent aluminum, has recently been announced as suitable for continuous service at 2,300 deg. F., as in stills.

Another important modification of the high-chromium steels is the addition of nitrogen to improve the grain structure, especially in steel castings containing more than 20 per cent chromium and used for resistance to corrosion, to high temperature, and to excessive wear. Such castings have shown a tendency toward the formation of a large grain structure and toward grain growth when held at a high temperature for long periods. The addition of nitrogen has the effect not only of reducing the tendency to grain growth at high temperature, but also of refining the grain initially, thereby resulting in a marked increase in ultimate strength, yield point, elongation and reduction of area. The nitrogen is added in the proportion of approximately one part of nitrogen to 120 parts of chromium, being introduced in the form of high-nitrogen ferrochrome. The nitrogen is added to chromium steel ingots, as well as to castings, the resulting fine grain making the alloy tough, ductile and more adaptable to deep drawing operations. Nitrogen-bearing high-chromium steel therefore appears to have valuable potentialities for manufacturers desiring a high quality corrosion-resistance seamless tubing.

The wider application of chromium steels, a greater variety of commercial ranges of chromium content, and modifications to include nitrogen, columbium, titanium, molybdenum, aluminum, nickel, or tungsten, are definite trends.

Exhibit Shows Steps in Developing Designs

AN EXHIBIT, claimed to be the first of its kind, revealing various stages in the design of a wide variety of familiar industrial products, has been opened in the School of Architecture of the Massachusetts Institute of Technology and will continue until January 9. The exhibit shows the varied and complex steps in the design of such widely differing products as clocks and fabrics, automobile parts and electric fans, perfume bottles and furniture, the purpose of the exhibit being to indicate how the designer works in developing the familiar products. In addition to showing the step by step development of such products, the exhibit offers some interesting biographical information on the designers themselves. The work in each case was selected because it represented some interesting point or points in technique, rather than because of the importance of the product itself.

Many of the exhibits show the working steps in the process of design, including original rough sketches, blueprints, drawings at various stages of development, survey material, variety in results, and in some cases, the marketing methods. Brought out clearly in these exhibits is the process by which a designer changes the artistic conception of the finished product in order to adapt it to the demands of the consumer and to quantity production.

Theodor Carl Muller, lecturer in design of manufactured products at Technology's School of Architecture, assembled the exhibits and arranged them. Examples of the work of more than 25 designers are on display.

MEETINGS

Society of Automotive Engineers—Annual meeting, Book Cadillac Hotel, Detroit, Mich., Jan. 11-15. John A. C. Warner, secretary, 29 W. 39th St., New York City.

American Road Builders Association—Annual meeting, Hotel Roosevelt, New Orleans, La., Jan. 11-15. Charles N. Upham, secretary, 952 National Press Building, Washington, D. C.

American Society of Heating and Ventilating Engineers — Annual meeting, Hotel Statler, St. Louis, Mo., Jan. 25-27. A. V. Hutchinson, secretary, 51 Madison Ave., New York City.

American Institute of Electrical Engineers—Annual winter convention, Engineering Societies Bldg., New York, N. Y., Jan. 25-29. H. H. Henline, secretary, 33 W. 39th St., New York, N. Y.

EXHIBITIONS

National Motor Boat Show—Grand Central Palace, New York City, Jan. 8-16. Ira Hand, manager, 420 Lexington Ave., New York, N. Y.

National Crushed Stone Association—Exhibits of crushing machinery, Grand Central Palace, New York City, Jan. 18-20. J. R. Boyd, manager, 1735-14th St., Washington, D. C.

First National Aviation Show—Grand Central Palace, New York City, Jan. 28-Feb. 6. G. A. Parsons, manager, 154 Randolph Ave., Waterbury, Conn.

High Tribute Paid to Dr. Rudolf Diesel

FORTY years ago Dr. Rudolf Diesel granted to Adolphus Busch of St. Louis the right to manufacture diesel engines in the United States. To honor the memory of Dr. Diesel on the fortieth anniversary of the introduction of diesel power to the United States, 350 leaders of the middle-west industrial, financial, political and educational world gathered in the Grand Ballroom of the Palmer House in Chicago on Monday noon, December 7. A huge lighted picture of the noted inventor of the diesel engine hung over the long speakers' table. In front of B. C. Heacock, president of Caterpillar Tractor Company and host for the luncheon, was a mammoth cake, glittering with 40 candles. Beyond, in the foyer, were a diesel tractor and a diesel-electric generating set, the last word in modern diesel design. Had the late Dr. Rudolf Diesel been present, he would have realized that those years of toil, tireless research and experiment, had not been spent in vain.

John B. Kennedy, noted radio news commentator and former editor of Collier's Magazine, was the principal speaker. He painted a brilliant word-picture, telling the diesel story from the layman's viewpoint in a simple and understanding manner. By simple comparison, Mr. Kennedy showed how the diesel engine made available power at a much lower cost and contributed directly to a higher plane of living.

Do You Know That—

• A new kind of paint, available in two types, changes color according to the temperature of the painted surface, the one type turning back to the original color when cooled, the other type remaining changed in color permanently. Used for indicating temperatures on motors, bearings, heated equipment, and similar products to indicate temperature, give warning of overheating, or give evidence of having been overheated. (36)

• A pale red copper alloy of unknown composition was discovered in Germany about 200 years ago and because it was extremely difficult to work and erratic in its behavior, it was named Nick-Kupfer, the English equivalent of which is "devil copper." In 1751 Cronstedt isolated the metal that gave the alloy its pale color and naturally called it nickel. (37)

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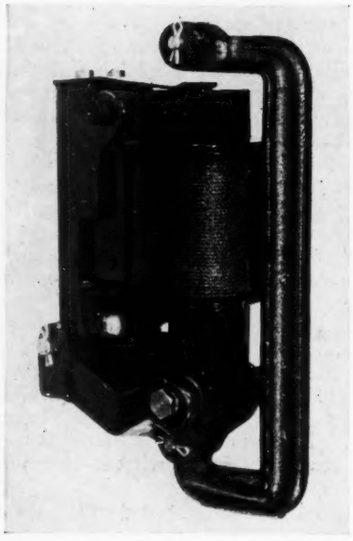
New Materials and Parts

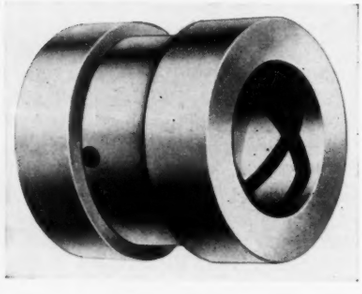
Solenoid

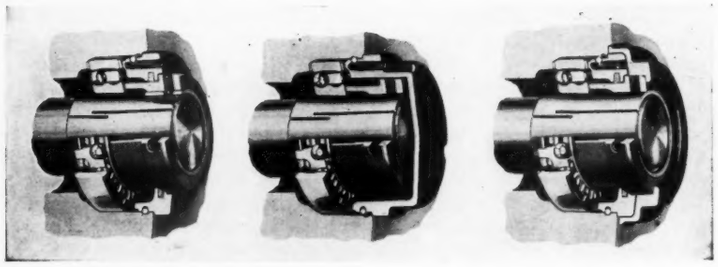


When the magnet is energized the movable core strikes the stationary core at two points completing a full magnet field. For "push up" operation a yoke is furnished as shown in illustration. Made in three sizes with 5, 10 and 15 lb. pull respectively, strokes are 1 in., with a length of $8\frac{3}{16}$ in. overall. C. J. Anderson & Co., 212–222 W. Austin Ave., Chicago, Ill.

Reservoir Bushings

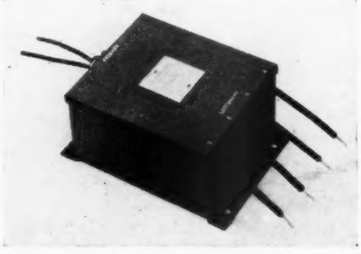
Supply automatic lubrication by feeding lubricant through graphite plugs. Graphite in machined grooves provides lubrication. In two types storage space is obtained by undercutting the outside surface. Two other types are for applications using a pocket in the bearing housing for a reservoir. Bushings can be reamed, broached or diamond bored after assembly without damaging the graphite. Randall Graphite Products Corp., 609–613 W. Lake St., Chicago, Ill.





Ball Bearing Machine Units

Facilitate the installation of ball bearings in machine assemblies where the bearing housing is either a part of the machine or must conform to the manufacturer's design. Three capacities are available for a given shaft size, in two types. All are equipped with self-aligning ball bearings to compensate for assembly inaccuracies and shaft deflections. Known by series numbers 21000, 23000, and 25000. Ahlberg Bearing Co., 317–329 E. 29th St., Chicago, Ill.



Signaling Transformer

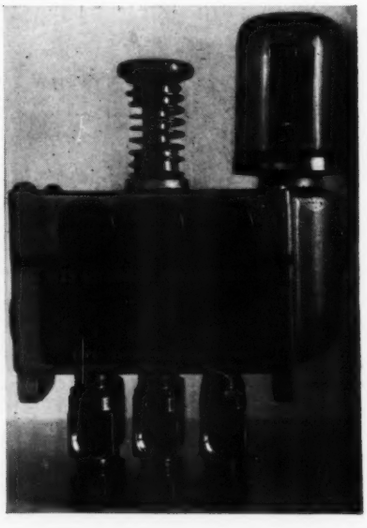
For general applications where a low-voltage a.c. power supply is required to operate bells, gongs and signalling systems. Core and windings are sealed in a steel case with a compound which makes the transformer moisture proof. The power ratings at taps are 100 volt-amperes at 24 volts, 67 volt-amperes at 16 volts, and 50 volt-amperes at 12 volts. Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

Wite-Brass Plate

Can be plated over any metal surface. Claimed to be as white as silver and non-tarnishing. Suitable for metal novelties, flatwear, optical goods and reflectors. A steel tank is used to hold the solution and also serves as anode. The bath operates at a temperature of 140 to 175 deg. F. at a current density of 25 amperes per sq. ft., and deposits at the same rate as does ordinary nickel. No after-buffing of plated work is required. Polished work when plated for as much as two hours obtains a mirror finish. The Alrose Chemical Co., Providence, R. I.

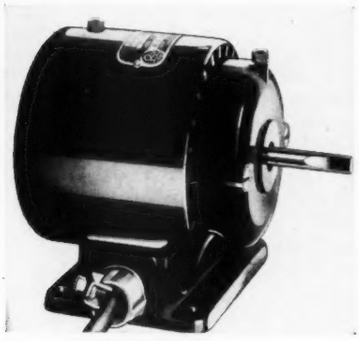
Automatic Multiple Oiler

For high-speed machinery where frequent oiling is necessary. Actuated by hand plunger to give one oiling with each down stroke. Bayonet type constant level oil reservoir and sight feeds are made of a transparent unbreakable plastic. Body is an aluminum die casting provided with mounting lugs. Adjustment screws on both sides of the box can be set to feed from 1 to 10 drops of oil. Oil-resisting synthetic-rubber flexible tubes can be supplied for leads. Available in styles with 2 to 12 leads. Gits Bros. Mfg. Co., 1859 S. Kilbourn Ave., Chicago, Ill.

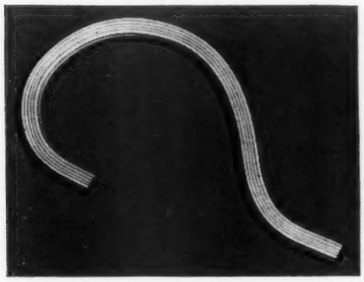


Shaded Pole Motor

Induction type recommended for air conditioning, refrigerating, heating and blowing equipment. Line consists of three styles, one has studs on shaft extension end of motor for direct mounting to driven unit, another has a cast iron base, and a third is mounted on rubber for quietness of operation. All have inclosed cooling fan. Housings are die castings. Sizes range from 1/25 to 1/125 hp., 110 or 220 v., 50 or 60 cycles, single phase, speed 1650 r.p.m., at 145 deg. F. operating temperature. A. G. Redmond Co., Flint, Mich.



Adjustable Drafting Curve



Made of white-metal impregnated rubber to reduce shadow and to prevent deterioration. Has a lead core between two spring steel strips for holding the desired shape or curve profile. The drawing edges are low, are undercut to prevent blotting, and are parallel. Available in stock lengths of 7, 15, 31, 48, 60 and 72 in. Wade Instrument Co., 2274 Brooklyn Station, Cleveland, Ohio.

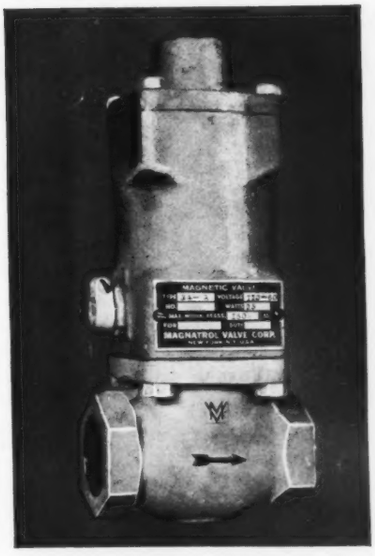
Coppercote

Minute flakes of copper suspended in a vehicle which when applied to wood, steel or concrete produces a corrosion-resistant coating impervious to air and water that will not crack, scale nor chip because of seasonal temperature changes. The metallic particles combine and adhere closely to the base. The vehicle rises and forms a second protective film. It is a nonconductor of electricity and not subject to destructive electrolytic action, is fire resistant, and will waterproof concrete floors, swimming pools, brick walls and similar surfaces. American Coppercote, Inc., 480 Lexington Ave., New York, N. Y.

Motor Starter

Pushbutton operated switch, motor is connected directly across the line on starting. For use with d.c. and single phase a.c. squirrel cage motors driving small machinery. Contact mechanism provides inverse time limit overload protection during starting and running. After circuit has been opened by an overload it automatically resets and motor is restarted by pushing reset button. Available in two types; skeleton and inclosed. Cutler-Hammer, Inc., 12th & St. Paul Ave., Milwaukee, Wis.

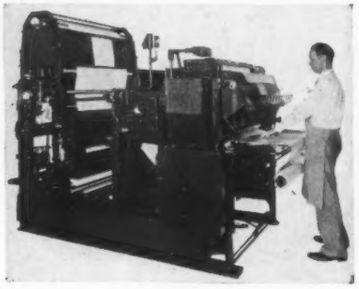
Magnetic Valve



Closing an electric circuit energizes solenoid which causes valve to open, when circuit is broken the valve shuts off by spring action. Suitable for air, gas, water, brine and oil service where a full flow is desired. Control is automatic or remote. Construction is packless. Self-contained electric outlet box in solenoid housing. Can be furnished with a hand lift for operating should power fail. Valves range from $\frac{1}{4}$ to 2 in. pipe size, for pressures up to 250 lb. per sq. in. Magnatrol Valve Corp., 52 Beekman St., New York, N. Y.

Blueprinting Machine

Prints, washes, develops and drys blueprints, negatives, blue- or brownline prints. Actinic light from arc lamps is used for exposure. Resistance coils for lamps are designed for wall mounting. Prints are run



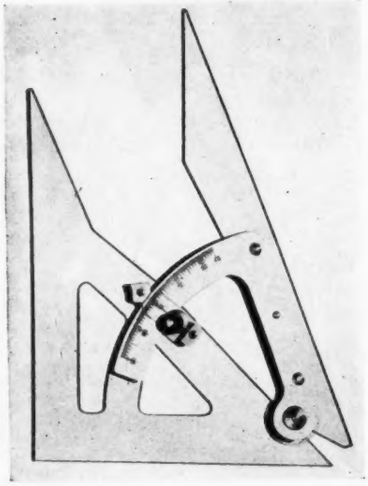
through a cleaning water wash, then passed through a developing process over a roll, and next washed with a spray jet. Machine is furnished with either a gas or electric type dryer, both types are available in either the radiator style or double drum ironing style. All heating units have adjustable controls. Frame work of all units is cast iron. Finish is enamel. Piping and wiring are complete upon delivery. Made in two models. Model "27" has a minimum speed of 8 in. per min. and a maximum of 13 ft. per min. Model "27-D" has a greater maximum speed, it is 14 ft. per min. C. F. Pease Co., 813–821 N. Franklin St., Chicago, Ill.

Variable-Speed Drive

Is provided with a V-belt pulley-drive. Speed adjustment is made by means of handle on outside of housing. The handle has a locking device to prevent movement. Steel casing covers motor and drive. Ventilation is provided with a fan type

pulley and louvres in casing. Bearings are equipped with high pressure lubrication fittings. Has a 3 to 1 variable speed ratio. Standard sizes range up to 7½ hp., made in vertical and horizontal types. Mechanical Handling Systems, Inc., Detroit, Mich.

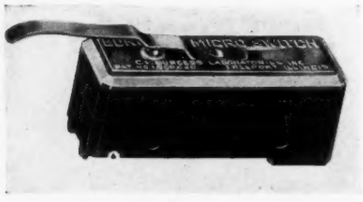
Improved Protractor Triangle



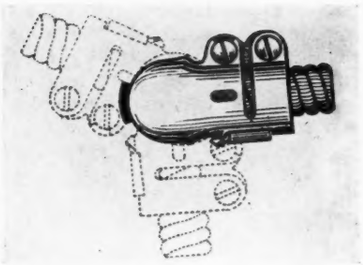
New nut eliminates former handling difficulties and adds to the appearance of the instrument. Height of the nut is increased to give greater distance to face of triangle affording more finger room when clamping, picking up the instrument or moving it on board. E. S. Brown, 78 Standart Ave., Auburn, N. Y.

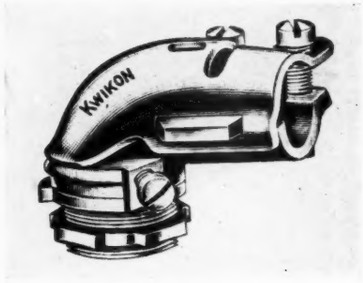
Spring Actuators

Facilitate application of micro switch to package counting machines and its use as a precision limit switch on machine tools. One type has a leaf spring operating lever which permits greater movement of the actuating element than does the standard plunger and requires less operating force. The spring can be made in any shape or length desired. A second type is a sleeve which fits over the standard



plunger, actuates the switch through a spring in the cap, and provides an overtravel of 1/16 in. after operation. C. F. Burgess Laboratories, Inc., Freeport, Ill.





Swivel Box Connector

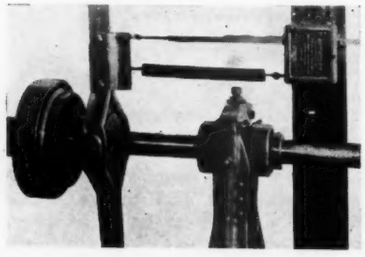
Facilitates the adjustment and alignment of cables after installation. Threaded shank is held rigid by locknut inside junction box. The body is free to rotate as a swivel on the shank and is locked at the desired angle by means of a set screw outside the box. The body is also provided with a clamp for BX armor sheath or other conduit. Kwikon Co., 612 W. Jackson Blvd., Chicago, Ill.

Rust Remover

Dissolves grease, oil, wax and oxidation on metal surfaces, used preparatory to applying a paint finish. Cleans and etches leaving a rustproofed surface. Diluted with 2 to 3 parts of water, it can be applied with cloth, brush or spray gun, and is removed by wiping with dry cloths or dipping in water. Its quick action makes it suitable for production work. It is known as Rusticide "50". It is non-inflammable, non-explosive, and non-toxic. Rusticide Products Co., Cleveland, Ohio.

Remote Clutch Release

Permits instant disengagement of a mechanical clutch by pressing a push-button conveniently located. Consists

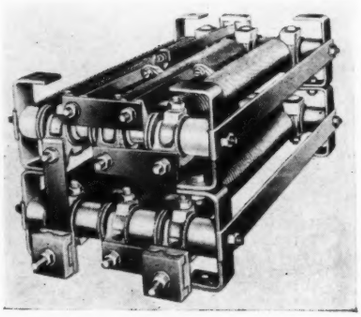


of an electro-mechanical latch mechanism connected to the yoke of a friction clutch with a spring and lever arrangement. Operates from lighting circuit which opens as soon as mechanism releases. One stroke of the manually operated clutch lever engages the clutch and latches the release mechanism. The Hilliard Corp., 102 W. Fourth St., Elmira, N. Y.

Trimetallic Contact Material

Built up of composite sheet metals. Consists of a silver or silver alloy face plate abutting against a high conducting cuprous metal layer and joined to an iron, steel, Monel metal or nickel backing. It is said to be efficient electrically and to possess high heat conductivity. It can be easily welded or attached to supporting members. Callite Products Co., 550-39th St., Union City, N. J.

Resistor



Has malleable iron terminal clamps supported directly from the frame to relieve the elements of cable strain and vibration. Heavy pressed steel terminals provide tap connections, the location of which can be quickly changed. All wiring and interconnections between banks are made at the end of frame. Said to be suitable in places subject to vibration and shocks where heavy currents are used. Monitor Controller Co., Baltimore, Md.

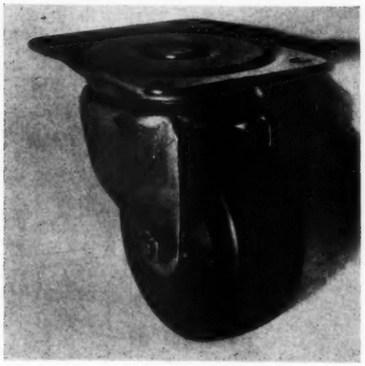
Watt-hour Meter

Has a specially designed single rotating disk which makes it possible for two electric elements to act with negligible electrical interference. New disk is composed of five laminations each having five radial slots. The laminations are assembled with insulation between them and with the slots staggered. Compensated for temperature errors, the meter will register energy consumption up to 300 per cent of normal load current at both

unity and one-half power factor. Available in two forms, the V-2A for wall or connection-box mounting, and the V-2S for socket mounting. General Electric Co.. Schenectady, N. Y.

Monel Caster

With wheels of special rubber composition for trucks, hampers and wheeled conveyors. For use in chemical and processing plants, laundries, and dry cleaning establish-



ments where corrosive materials may spill over on floor. All metal parts are made entirely of Monel metal. Bassick Co., Bridgeport, Conn.

Murex Electrodes

Designed for bridging gaps where fit-up between plates is poor. Smaller sizes can be used on vertical and overhead work or for single pass welds on light gage materials. It will produce single or multiple pass fillets. Physical properties of deposited metal range from 74,000 to 84,000 lb. per sq. in. tensile strength with 24 to 26 per cent ductility. Known as Murex Type N, will work with either d.c. or a.c., with straight or reversed polarity. Metal & Thermit Corp., 120 Broadway, New York, N. Y.

MANUFACTURERS' PUBLICATIONS

Air Operated Controllers — The Brown Instrument Co., Philadelphia, Pa. Catalog No. 8901, 32 pages, 8 x 10½ in. Explains in non-technical language the principle of operation and air operated controllers for temperature, pressure, flow and liquid level, contains many diagrams illustrating construction and installation hook-ups.

Ball Bearing Machine Units—Ahlberg Bearing Co., 317–329 E. 29th St., Chicago, Ill. Circular, 8 pages, 8½ x 11 in. Dimensional cuts and tables with description of three new series of ball bearing machine units for machine applications.

Bearings for Aircraft—The Timken Roller Bearing Co., Canton, Ohio. Engineering Journal, pages 1102–1114 inc., 8⅜ x 10¾ in. Covers the application of tapered roller bearings to landing wheels, tail wheels, swivels and rocker arm assembles. Complete design data and weights are given with dimensional cuts and tables.

Boiler Water Level Control—McDonell & Miller, Wrigley Bldg., Chicago, Ill. Catalog No. 36, 32 pages, 8½ x 11 in. Illustrates manufacture, construction and installations of various types of boiler water feeders and level controls, switches, low-water cutoffs, and valves for humidifier pans.

Brass and Copper Stock List—T. E. Conklin Brass & Copper Co., Inc., 54–60 Lafayette St., New York, N. Y. Stock list No. 12, 200 pages, 4¼ x 9¼ in. Consists chiefly of tables giving stock sizes and weights of copper, brass, bronze, nickel silver, and special copper base metals in the form of sheets, rods, wire, tubes and shapes. Rivets, burs, washers, fittings, wire cloth, nails, bolts and screws are also listed. Handy data tables make up the appendix.

Bristo Screw Products—The Bristol Co., Waterbury, Conn., Bulletin 833, Folder 3½ x 6¼ in. Standard stock sizes and types of set and capscrews, also stripper bolts and pipe plugs, with multiple spline sockets presented in table form.

Chain and Attachments—American Chain Co., Inc., Bridgeport, Conn. Two new catalogs, each 44 pages, 8½ x 11 in. Catalog No. 365, covers welded chain and attachments used for light and heavy service for use in fabricated assemblies, maintenance service and material handling operations. Catalog No. 366, describes chains made from wire into various patterns by knotting to form the links, or by stamping from flat metals.

Colmonoy No. 6—Colmonoy Co., Los Nietos, Calif., 12 pages, 3½ x 6 in. Describes a wear-resistant, corrosion-resistant, non-oxidizing alloy that can be cast into shapes and also welded on as an over-lay.

Induction Motors—General Electric Co., Schenectady, N. Y. Six folders, each 8 x 10½ in. They describe and illustrate the construction and characteristics of riveted frame motors of the following induction types, totally inclosed fan-cooled, explosion-proof, totally inclosed for hoist installations, type K totally inclosed, general-purpose squirrel-cage, and splash proof.

Stainless Welded Tubing—Carpenter Steel Co., 347 Madison Ave., New York, N. Y. Bulletin, 8 pages, 8½x11 in. Tells how welded stainless tubing is made and illustrates available standard and special shapes. Technical data, working instructions, and recommended uses are included.

Story of Manganese Steel—American Manganese Steel Co., Chicago Heights, Ill. Folder, 6 pages 8½x11 in. Short descriptions of manganese steel, chemical content, physical properties, method of manufacture, and applications.

Temperature Control Units—Foxboro Co., Foxboro, Mass. Bulletin 194-1, 20 pages, 8½x11 in. Reviews the potentiometric method of temperature measurements used by Stabilog air-operated continuous-control systems. Discusses recording units for checking on temperature maintenance; also valve flow characteristics. Included are specifications and ranges for thermocouples, resistance bulbs and other accessories.

Temperature Controls and Thermal Relays—Edison Electrical Control Div. of Thomas A. Edison, Inc., West Orange, N. J. 9 x 11¼ in., 24 pages, describes construction and types of temperature controls and thermal relays, lists industrial applications, engineering data tables and characteristics.

Thermostatic Bimetal—Callite Products Co., 540 Thirty-Ninth St., Union City, N. J. Folder, 4¼x9¾ in. Describes types of Calliflex thermostatic bimetal and precious metal contact points.

Thermocouple Pyrometers—Leeds & Northrup Co., 4900 Stenton Ave., Philadelphia, Pa. Catalog N-33A, 52 pages, 7¾x10½ in. Explains the potentiometer method of measurement and the operation of the mechanisms using the balance principle. The complete line of Micromax instruments are described and illustrated with models for indicating, recording, signaling, controlling, or performing these functions in combination.

Vibrating Screens—Link-Belt Co., 2045 W. Hunting Park Ave., Philadelphia, Pa. Catalog No. 1562, 24 pages, 8½x11 in. Describes vibrating screens of the unbalanced-pulley and the positive drive types for screening coal, sand, gravel, ore and similar materials. Complete with clearance diagrams and dimension tables.

Vibro-Dampers—Korfund Co., Inc., Long Island City, L. I., N. Y. Folder, four pages, 8½x11 in. Describes the advantages, uses of, and applications of spring dampers used in setting up machinery.

Water Pipe Sizes for Plumbing—Bridgeport Brass Co., Bridgeport, Conn. 48 pages, 5½ x 8½ in. Revised edition of tables and data on water pipe sizes, with new information on flow of water in copper water tubes, with further specifications on plumbers' brass goods, used for air conditioning and refreigeration.

BOOKS AND BULLETINS

Handbook of Chemistry and Physics

Charles D. Hodgman. 2,033 pages, 4¼x6½ in. Semi-flexible black leatherette covers. Published by Chemical Rubber Publishing Co., West 112th St. and Locust Ave., Cleveland, Ohio. Price $6.

New publication has 64 more pages than the preceding edition, with many revised tables. The collection of data covering commercial plastics is new; it lists trade names, names of manufacturers, physical and chemical properties of many thermo-plastic and thermo-setting compounds. A table of natural sines has been added. Tables of reciprocals, squares, cubes and roots have been rearranged. Several new small tables are included and a number of minor changes have been made.

Machine Designers' Guide

K. W. Najder. 243 pages, 5¼x8 in. Numerous line cuts and tables. Green clothboard covers. Published by K. W. Najder, Lake Orion, Mich. Price $2.75.

The present volume is the second edition of this practical book, the principal aim of which is a simple and clear treatment of the problems met with in the work of the engineer and designer. It presents the manner of procedure, the applications of formulas and methods used in solving engineering problems without the use of higher mathematics. Some new problems have been added to the sections on mechanics, graphics, and strength of materials. This new edition has added a few pages covering spur gears, U.S. Standard screws, S.A.E. screws, and natural trigonometric tables.

Wrought Iron

Manufacture, Characteristics and Applications

James Aston and *Edward B. Story.* 59 pages, 6x9 in. Illustrated. Green clothboard covers. Published by A. M. Byers Co., Pittsburgh, Pa. Price $1, but free to executives applying on their company letterhead.

This handbook was written to meet the demand for information concerning the qualities of wrought iron products and to supply this data to those interested in ferrous metals. The early methods of manufacturing wrought iron are described and are contrasted with present day methods of manufacturing the product. Quality standards, characteristics, and applications of wrought iron are presented in interesting form. A two-page glossary of terms forms a useful appendix.

Ingenious Mechanisms for Designers and Inventors. Vol. II

Franklin D. Jones. 538 pages, 6x9 in. Green clothboard covers, 303 illustrations. Published by The Industrial Press, 140-148 Lafayette St., New York, N. Y. Price $5.

A companion of Vol. I, this book deals with various types of mechanisms and mechanical devices covering the field of design. The subjects discussed and illustrated in 17 chapters pertain to cam applications and special cam designs; intermittent motions for gears, cams, ratchet gearing, and Geneva motions; tripping or stop mechanisms; over-load relief mechanisms and automatic safeguards; reversing mechanisms; reciprocating crank drives; reciprocating motions for cams, gears and levers; speed changing mechanisms and transmissions; over-running clutches; self-centering levers and members, feeding mechanisms and auxiliary devices; feeding and ejecting devices for power presses and valve diagrams.

The illustrations and descriptions are confined to the important elements of mechanisms which have been tried and tested. All similar devices are grouped according to general types and an index is included to facilitate finding any desired mechanism.

Mechanical Power Transmission Handbook

William Staniar. 488 pages, 6x9 in. Semi-flexible green covers. 190 illustrations, 242 tables. Published by McGraw-Hill Book Co., Inc., 330 West 42d St., New York, N. Y. Price $5.

The aim of this book is to be of assistance to engineers in the proper selection and application of mechanical power transmission equipment. Latest developments in equipment, methods and practices are embodied within its pages. Fifteen chapters treat such subjects as pulleys and belting, steel shafting, bearings, clutches, couplings and collars, short center driving methods, chain drives, mechanical transmission systems, high-starting-torque devices, infinitely variable speed control, gear reduction units, lubrication of mechanical power equipment and electric motors.

The various tables pertain to horsepower capacities, speeds, sizes, torques, dimensions, properties, ratings, types and constants, of the various units and devices. Many photographs and line drawings illustrate design, methods, installation, comparative sizes and other general data with which the designing engineer should be acquainted.

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The Answer to Rolling Mill Bearing Problems

The Timken Roller Bearing Co., Canton, Ohio. Booklet, 64 pages, 8½x11 in. Paper covers.

This booklet describes and illustrates with photographs and diagrams typical applications of Timken bearings to rolling mill equipment. More than 20 pages of the booklet are devoted to a listing of Timken equipped rolling mills, main rod drives and rolling mill pinion stands, giving name of company using the equipment, type and size of the installation, the position in which the bearings are used, the bearing numbers and other pertinent information.

Quenched and Tempered Nickel Alloy Steels

The International Nickel Co., Inc., 67 Wall St., New York, N. Y. 103 pages, 6½x8¾ in. Revised Section II, Data Sheet No. 4 for their loose-leaf data book "Nickel Alloy Steels," which is bound in a sectioniter type binder to provide for additions or replacements.

The steels listed in this section of the data book are carbon, nickel, nickel-chromium, nickel-molybdenum, nickel-chromium-molybdenum, nickel-chromium-vanadium (carburizing), divided into two classes: carburizing steels and oil and water hardening steels.

The introductory chapter covers the chemical compositions of quenched and tempered nickel alloy steels in sections up to about 6 in. in diam. or thickness, with recommendations for their selection for particular applications. Following this are more than 75 pages devoted to mechanical property charts for nickel alloy steels heat-treated in small sections (about ½ to 1½ in. in diam. or thickness), charts showing the effect of size on the tensile properties of quenched and tempered nickel alloy steels (from ½ to about 6 in. in diam.), and charts showing the torsional properties of quenched and tempered nickel alloy steels in a range of different sizes.

Comparative Serial Numbers of Standard V-Belts

Note—Included angle of belt sides is 42 deg. For fractional hp. drives, V-belts 3/8 in. wide by 1/4 in. thick are obtainable.

Width in in.	Thickness in in.	Pitch Length in in.	Allis-Chalmers	Former Allis-Chalmers	Dayton	Dodge	Fairbanks-Morse	Gates	Gilmer	Manhattan	Worthington-Goodyear	Former Worthington-Goodyear
1/2	11/32	27.0	A26	10A	2A8	A26	—	26A	2A6	A26	A26	0270
1/2	11/32	32.0	A31	10B	3A3	A31	—	31A	3A1	A31	A31	0320
1/2	11/32	36.0	A35	10	3A7	A35	1–A	35A	3A5	A35	A35	0360
1/2	11/32	39.0	A38	20B	4A0	A38	—	38A	3A8	A38	A38	0390
1/2	11/32	43.0	A42	20	4A4	A42	2–A	42A	4A2	A42	A42	0430
1/2	11/32	47.0	A46	30A	4A9	A46	—	46A	4A6	A46	A46	0470
1/2	11/32	52.0	A51	30	5A4	A51	3–A	51A	5A1	A51	A51	0520
1/2	11/32	61.0	A60	40	6A3	A60	4–A	60A	6A0	A60	A60	0610
1/2	11/32	69.0	A68	40B	7A1	A68	—	68A	6A8	A68	A68	0690
1/2	11/32	76.0	A75	50	7A8	A75	5–A	75A	7A5	A75	A75	0760
1/2	11/32	81.0	A80	50A	8A3	A80	6–A	80A	8A0	A80	A80	0810
1/2	11/32	86.0	A85	50B	8A8	A85	—	85A	8A5	A85	A85	0860
1/2	11/32	91.0	A90	60	9A3	A90	7–A	90A	9A0	A90	A90	0910
1/2	11/32	97.0	A96	60A	9A9	A96	—	96A	9A6	A96	A96	0970
1/2	11/32	106.0	A105	70	1A08	A105	8–A	105A	1A05	A105	A105	01060
1/2	11/32	113.0	A112	70A	1A15	A112	—	112A	1A12	A112	A112	01130
1/2	11/32	121.0	A120	80	1A23	A120	9–A	120A	1A20	A120	A120	01210
1/2	11/32	129.0	A128	80A	1A31	A128	—	128A	1A28	A128	A128	01290
21/32	7/16	36.4	B35	11	3B7	B35	1–B	35B	3B5	B35	B35	1364
21/32	7/16	39.4	B38	11A	4B0	B38	2–B	38B	3B8	B38	B38	1394
21/32	7/16	43.4	B42	21	4B4	B42	3–B	42B	4B2	B42	B42	1434
21/32	7/16	47.4	B46	21A	4B9	B46	4–B	46B	4B6	B46	B46	1474
21/32	7/16	52.4	B51	31	5B4	B51	5–B	51B	5B1	B51	B51	1524
21/32	7/16	56.4	B55	31A	5B9	—	—	55B	5B5	B55	B55	1564
21/32	7/16	61.4	B60	41	6B3	B60	6–B	60B	6B0	B60	B60	1614
21/32	7/16	66.4	—	—	—	—	—	65B	6B5	B65	B65	1664
21/32	7/16	69.4	B68	41A	7B1	B68	7–B	68B	6B8	B68	B68	1694
21/32	7/16	76.4	B75	51	7B8	B75	8–B	75B	7B5	B75	B75	1764
21/32	7/16	82.4	B81	51C	8B4	B81	—	81B	8B1	B81	B81	1824
21/32	7/16	86.4	B85	51A	8B8	B85	9–B	85B	8B5	B85	B85	1864
21/32	7/16	91.4	B90	61	9B3	B90	10–B	90B	9B0	B90	B90	1914
21/32	7/16	94.4	—	—	—	—	—	93B	9B3	B93	B93	1944
21/32	7/16	98.9	B97	61A	9B9	B97	11–B	97B	9B7	B97	B97	1989
21/32	7/16	101.4	—	—	—	—	—	100B	1B00	B100	B100	11014
21/32	7/16	104.4	—	—	—	—	—	103B	1B03	B103	B103	11044
21/32	7/16	106.4	B105	71	1B08	B105	12–B	105B	1B05	B105	B105	11064
21/32	7/16	113.9	B112	71A	1B15	B112	13–B	112B	1B12	B112	B112	11139
21/32	7/16	121.4	B120	81	1B23	B120	14–B	120B	1B20	B120	B120	11214
21/32	7/16	129.4	B128	81A	1B31	B128	15–B	128B	1B28	B128	B128	11294
21/32	7/16	145.4	B144	91	1B47	B144	16–B	144B	1B44	B144	B144	11454
21/32	7/16	159.4	B158	91A	1B61	B158	17–B	158B	1B58	B158	B158	11594
21/32	7/16	174.4	B173	91B	1B76	B173	18–B	173B	1B73	B173	B173	11744
21/32	7/16	181.4	B180	101	1B84	B180	19–B	180B	1B80	B180	B180	11814
21/32	7/16	196.4	B195	101B	1B99	B195	—	195B	1B95	B195	B195	11964
21/32	7/16	211.4	B210	101A	2B14	B210	—	210B	2B10	B210	B210	12114
21/32	7/16	240.0	B240	111	2B44	B240	20–B	240B	2B38	B240	B240	12400
21/32	7/16	270.0	B270	111A	2B74	B270	—	270B	2B68	B270	B270	12700
21/32	7/16	300.0	B300	121	3B04	B300	21–B	300B	2B98	B300	B300	13000

(CONTINUED ON NEXT PAGE)

Comparative Serial Numbers of Standard V-Belts

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(CONTINUED FROM PRECEDING PAGE)

Width in in.	Thickness in in.	Pitch Length in in.	Allis-Chalmers	Former Allis-Chalmers	Dayton	Dodge	Fairbanks-Morse	Gates	Gilmer	Manhattan	Worthington-Goodyear	Former Worthington-Goodyear
7/8	17/32	53.0	C51	32	5C4	C51	1–C	51C	5C1	C51	C51	2530
7/8	17/32	62.0	C60	42	6C3	C60	2–C	60C	6C0	C60	C60	2620
7/8	17/32	70.0	C68	42A	7C1	C68	—	68C	6C8	C68	C68	2700
7/8	17/32	77.0	C75	52	7C8	C75	3–C	75C	7C5	C75	C75	2770
7/8	17/32	83.0	C81	52A	8C4	C81	4–C	81C	8C1	C81	C81	2830
7/8	17/32	86.0	C85	52B	8C8	C85	—	85C	8C5	C85	C85	2860
7/8	17/32	92.0	C90	62	9C3	C90	5–C	90C	9C0	C90	C90	2920
7/8	17/32	98.0	C96	62A	9C9	C96	6–C	96C	9C6	C96	C96	2980
7/8	17/32	107.0	C105	72	1C08	C105	7–C	105C	1C05	C105	C105	21070
7/8	17/32	114.0	C112	72A	1C15	C112	—	112C	1C12	C112	C112	21140
7/8	17/32	122.0	C120	82	1C23	C120	8–C	120C	1C20	C120	C120	21220
7/8	17/32	130.0	C128	82A	1C31	C128	9–C	128C	1C28	C128	C128	21300
7/8	17/32	146.0	C144	92	1C47	C144	10–C	144C	1C44	C144	C144	21460
7/8	17/32	160.0	C158	92C	1C61	C158	—	158C	1C58	C158	C158	21600
7/8	17/32	164.0	C162	92A	1C65	—	—	162C	1C62	C162	C162	21640
7/8	17/32	175.0	C173	92B	1C76	C173	—	173C	1C73	C173	C173	21750
7/8	17/32	182.0	C180	102	1C84	C180	11–C	180C	1C80	C180	C180	21820
7/8	17/32	197.0	C195	102B	1C99	C195	—	195C	1C95	C195	C195	21970
7/8	17/32	213.0	C210	102A	2C14	C210	12–C	210C	2C10	C210	C210	22130
7/8	17/32	240.0	C240	112	2C44	C240	13–C	240C	2C38	C240	C240	22400
7/8	17/32	270.0	C270	112A	2C74	C270	14–C	270C	2C68	C270	C270	22700
7/8	17/32	300.0	C300	122	3C04	C300	15–C	300C	2C98	C300	C300	23000
7/8	17/32	330.0	C330	122B	3C34	C330	—	330C	3C28	C330	C330	23300
7/8	17/32	360.0	C360	132	3C64	C360	—	360C	3C58	C360	C360	23600
1–1/4	3/4	122.4	D120	83	1D23	D120	1–D	120D	1D20	D120	D120	31224
1–1/4	3/4	130.4	D128	83A	1D31	D128	2–D	128D	1D28	D128	D128	31304
1–1/4	3/4	146.4	D144	93	1D47	D144	3–D	144D	1D44	D144	D144	31464
1–1/4	3/4	160.4	D158	93B	1D61	D158	—	158D	1D58	D158	D158	31604
1–1/4	3/4	164.4	D162	93A	1D65	—	—	162D	1D62	D162	D162	31644
1–1/4	3/4	175.4	D173	93C	1D76	D173	—	173D	1D73	D173	D173	31754
1–1/4	3/4	182.4	D180	103	1D84	D180	4–D	180D	1D80	D180	D180	31824
1–1/4	3/4	197.6	D195	103B	1D99	D195	—	195D	1D95	D195	D195	31976
1–1/4	3/4	213.1	D210	103A	2D14	D210	5–D	210D	2D10	D210	D210	32131
1–1/4	3/4	240.0	D240	113	2D44	D240	6–D	240D	2D38	D240	D240	32400
1–1/4	3/4	270.0	D270	113A	2D74	D270	7–D	270D	2D68	D270	D270	32700
1–1/4	3/4	300.0	D300	123	3D04	D300	8–D	300D	2D98	D300	D300	33000
1–1/4	3/4	330.0	D330	123B	3D34	D330	—	330D	3D28	D330	D330	33300
1–1/4	3/4	360.0	D360	133	3D64	D360	9–D	360D	3D58	D360	D360	33600
1–1/2	1	183.1	E180	104	1E84	E180	1–E	180E	1E80	E180	E180	41831
1–1/2	1	198.5	E195	104B	1E99	E195	—	195E	1E95	E195	E195	41985
1–1/2	1	213.6	E210	104A	2E14	E210	2–E	210E	2E10	E210	E210	42136
1–1/2	1	240.0	E240	114	2E44	E240	3–E	240E	2E38	E240	E240	42400
1–1/2	1	270.0	E270	114A	2E74	E270	4–E	270E	2E68	E270	E270	42700
1–1/2	1	300.0	E300	124	3E04	E300	5–E	300E	2E98	E300	E300	43000
1–1/2	1	330.0	E330	124B	3E34	E330	—	330E	3E28	E330	E330	43300
1–1/2	1	360.0	E360	134	3E64	E360	6–E	360E	3E58	E360	E360	43600